STAMFORD®

Installation, Service and Maintenance Manual

For

STAMFORD P80 Generators

LVSI804, MVSI804, HVSI804, LVSM804

Original Instructions

SAFETY PRECAUTIONS

Before operating the generating set, read the generating set operation manual and the AvK 'Installation Service & Maintenance Manual' (supplied with the generator) and become familiar with them and the equipment.

This guide is in no way a replacement for internationally recognized standards for installations of such equipment and should be reviewed as an addition to such literature.

Warning!

Safe and efficient operation can only be achieved if the equipment is correctly installed, operated and maintained.

Many accidents occur because of a failure to follow fundamental rules and precautions.

Danger!

Electrical shock can cause severe personal injury or death.

- Observe all WARNING / DANGER notices.
- Ensure installation meets all applicable safety and local electrical codes. Have all installations performed by qualified installation technicians.
- Do not operate the generator with protective covers, access covers or terminal box covers removed.
- Disable engine starting circuits before carrying out maintenance.
- Disable closing circuits, lock out breakers and place warning notices on all circuit breakers to ensure complete circuit isolation from the mains or other generators before carrying out maintenance.
- Observe all IMPORTANT, CAUTION, WARNING and DANGER notices, defined as:

Caution! **Caution, refers to hazard or unsafe method or practice which can result in product damage or injury to personnel.**

Warning!

Warning, refers to a hazard or unsafe method or practice that can result in severe injury to personnel, possibly death.

Danger!

Danger, refers to immediate hazards which will result in severe injury or death to personnel.

Due to our policy of continuous improvement, details in this manual which were correct at the time of printing, may now be due for amendment. Information included must therefore not be regarded as binding.

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FOREWORD

The function of this book is to provide the user of the AvK generator with an understanding of the principles of operation, the criteria for which the generator has been designed, and the installation and maintenance procedures. Specific areas where the lack of care or use of incorrect procedures could lead to equipment damage and / or personal injury are highlighted with WARNING and / or CAUTION notes. It is important that the contents of this book are read and understood before proceeding to fit or use the generator.

The Service, Sales and Technical staff of AvK are always ready to assist. Reference to the company for advice is welcomed.

Warning!

Incorrect installation, operation, servicing or replacement of parts can result in severe personal injury or death and / or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.

Standards.

Generators covered by this manual meet the relevant parts of national and international standards pertaining to generators. The generator must be operated within the limits laid down in the relevant standards and within the parameters on the generator rating plate.
Marine generators meet the requirements of all the major marine classification societies.

European Directives.

AC generators sold for use in the European Union must meet the relevant European directives. An ac generator has no intrinsic function; it must be have a mechanic input in order to provide an electrical output. The generator is supplied as a component part of a Generating-Set. To reflect this each generator is supplied with an 'EC Declaration of Incorporation' in accordance the Machinery Directive.

The ac generator meets the relevant directives applicable to an ac generator (component part) before it is incorporated into 'machinery'.
The directives identified as pertaining to ac generators are:

- The Machinery (Safety) Directive, 98/37/EEC.
- The Low Voltage Directive, 73/23/EEC.
- The EMC Directive, 89/336/EEC

EC Declaration of Conformity

Generator Technologies

This synchronous a.c. generator is designed for incorporation into an electricity generating-set and fulfils all the relevant provisions of the following EC Directive(s) when installed in accordance with the installation instructions contained in the product documentation:

2006/95/EC	Low Voltage Directive
2004/108/EC	The EMC directive
2006/42/EC	The Machinery Directive

and that the standards and/or technical specifications referenced below have been applied:

EN 61000-6-1:2007	Electromagnetic compatibility (EMC). Generic standards – Part 6-1: Immunity for residential, commercial and light-industrial environments
EN 61000-6-2:2005	Electromagnetic compatibility (EMC). Generic standards – Part 6-2: Immunity for industrial environments
EN 61000-6-4:2007	Electromagnetic compatibility (EMC). Generic standards – Part 6-4: Emission standard for industrial environments
EN ISO 12100-1:2003	Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology
EN ISO 12100-1:2003	Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles
EN ISO 14121-1:2007	Safety of machinery - Risk assessment - Part 1: Principles
EN 60034-1:2004	Rotating electrical machines - Part 1: Rating and performance
BS ISO 8528-3:2005	Reciprocating internal combustion engine driven alternating current generating sets - Part 3: Alternating current generators for generating sets
BS 5000-3:2006	Rotating electrical machines of particular types or for particular applications - Part 3: Generators to be driven by reciprocating internal combustion engines - Requirements for resistance to vibration

The manufacturer's authorised representative in the Community and person empowered to draw up this declaration and to compile the relevant technical documentation, on behalf of the manufacturer is Mr Jeffrey Matthews - Director Engineering, Cummins Generator Technologies, Barnack Road, Stamford, Lincolnshire, PE9 2NB, England.

Signed: Date: 21st December 2009

Description Serial Number

DRAWING REF 450-1 6333-S

Registered in England under Registration No. 441273.
Cummins Generator Technologies Ltd. Registered Office: Barnack Road, Stamford, Lincolnshire PE9 2NB, England.

The generator is CE marked; CE labels are supplied loose in case the generating set manufacturer needs to paint the generating set before delivery to the end user.

Note: Once the generator is build into a generating-set (machinery), it is the responsibility of the generating-set manufacture to ensure that the generating-set complies with the relevant EC Directives.

It is contrary to the EC Directives to misrepresent compliance of the EC directives by displaying the CE mark supplied with a component part of the product. The directive requires compliance to be assessed as a component part, as the complete product and during installation on site.

Applications for use within the EU

STAMFORD ac generators are supplied on the basis that:

- They are used for power generation or related functions.
- They are to be applied in one of the following environments:
  Portable (open construction – temporary site supply)
  Portable (enclosed – temporary site supply)
  Containerised (temporary or permanent site supply)
  Ship – borne, below decks (marine auxiliary power)
  Commercial vehicle (road transport / refrigeration etc.)

Road transport (auxiliary power)
Industrial vehicle (earthmoving, cranes etc.)
Fixed installation (Industrial – factory / process plant)
Fixed installation (residential, commercial and light industrial – home / office / health.)
Energy management (combined heat & power and/or peak lopping.)
Alternative energy schemes.

- The standard generators are designed to meet the 'industrial' emissions and immunity standards. Where the generator is required to meet the residential, commercial and light industrial emissions and immunity standards reference must be made to document reference N4/X/011. This publication outlines the additional equipment that may be required.
- The installation 'earth/ground' arrangements require the connection of the generator frame to the site protective earth conductor using a minimum lead length.
- Maintenance and servicing with unauthorised parts, not of supply, will invalidate us from any liability for EMC compliance.
- Installation, maintenance and servicing are carried out by adequately trained personnel fully aware of the requirements of the relevant EC directives.

Unsuitable Applications

Synchronous generators require a constant speed for power generation. Applications where the generator is not run at a constant speed are not suitable for the standard generator. Such applications may be possible within certain parameters. Contact the factory for advice, there is every possibility that we can provide you with a satisfactory technical solution to meet your requirement.

Additional information for EMC compliance

Standard generators are designed to meet the 'industrial' emissions and immunity standards. Where the generator is required to meet the residential, commercial and light industrial emissions and immunity standards, reference must be made to document reference N4/X/011. This publication outlines the additional equipment that may be required.

CE

1. Introduction

P80 – Low Voltage (LV)
The LV range of generators is of brushless rotating field design, available up to 1000 V/50 Hz (1500 rpm, 4 pole) and 1000 V/60 Hz (1800 rpm, 4 pole) and built to meet BSEN 60034-1, BS5000 Part 3 and other appropriate international standards

P80 – Medium Voltage (MV)
The MV range of generators is of brushless rotating field design, available up to 3.3 kV/50 Hz (1500 rpm, 4 pole) and built to meet BSEN 60034-1, BS5000 Part 3 and other appropriate international standards.

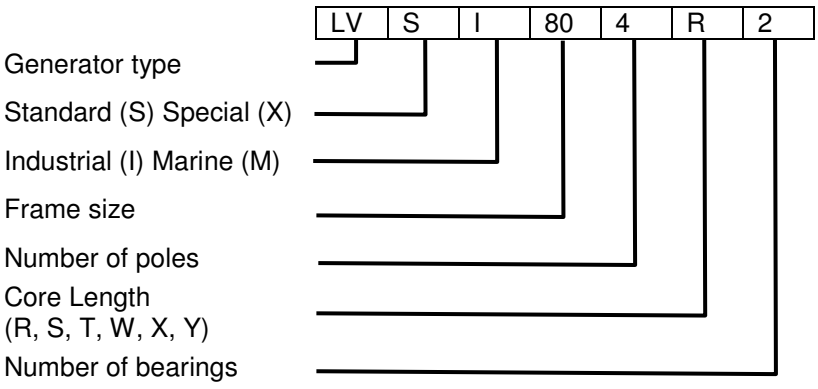
P80 – High Voltage (HV)
The HV range of generators is of brushless rotating field design, available up to 15 kV/50 Hz (1500 rpm, 4 pole) and 13.8 kV/60 Hz (1800 rpm, 4 pole) and built to meet BSEN 60034-1, BS5000 Part 3 and other appropriate international standards.

All P80 range generators use a permanent magnet generator (PMG) excitation system incorporating an automatic voltage regulator (AVR). AVR type and specification are dependent on P80 model and customer requirements; please refer to the AVR manual provided with the generator or download from www.stamford-avk.com

Note: If the manufacturer supplied AVR system is to be replaced by the customers own, consult with Cummins Generator Technologies prior to use, to ensure its compatibility.

1.1. Designation

The generator frame size is designated by a code as follows:



1.2. Serial number designation

Each generator has its own unique serial number stamped into the upper section of the frames drive-end end plate.

Inside the terminal box two adhesive labels have been fixed, each carrying the generators unique identity numbers.

One label has been fixed to the inside of the terminal box sheet metal work, and the second label fixed to the saddle, supporting the terminal box.

1.3. Rating plate

The generator has been supplied with a self-adhesive rating plate label to enable fitting after final assembly and painting.

It is intended that this label will be stuck to the outside of the NDE of the terminal box.

The surface in the area where a label is to be stuck must be flat, clean and any paint finish be fully dry before attempting to attach the label. Recommended method for attaching the label is to peel and fold back sufficient of the backing paper to expose some 20 mm of label adhesive along the top edge. Once this first section of the label has been carefully located and stuck into position, the backing paper can be progressively removed, as the label is pressed into position. The adhesive will achieve a permanent bond in 24 hours

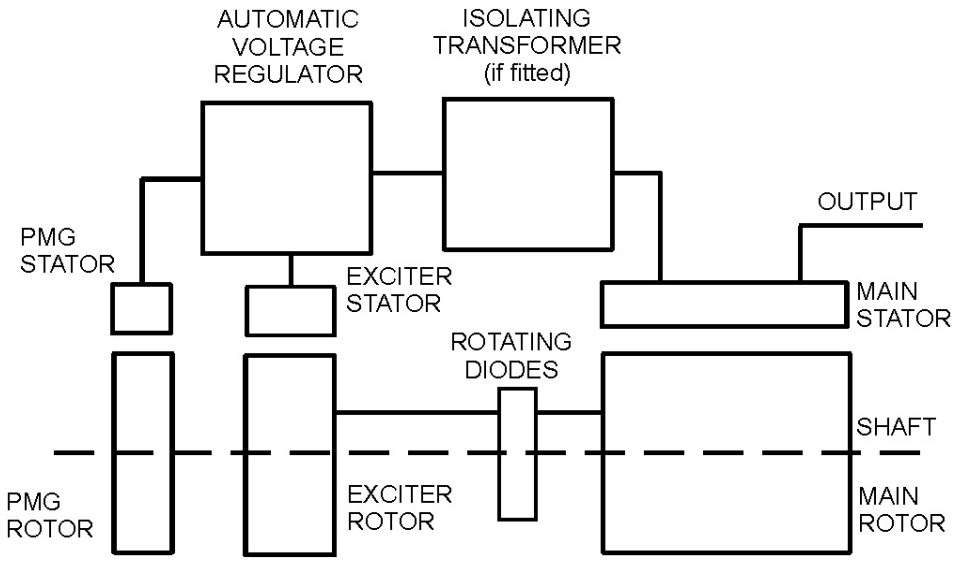
1.4. Bearing grease information

A self-adhesive label will have been fixed to the end plate above the bearing giving information about the bearing grease type, re-lubrication frequency and quantities.

1.5. Fasteners

It is important that fasteners which locate / secure structural components are all fully tightened to the required torque setting (see table 7-2 / figure 7-3, Service and Maintenance Manual) before the machine is run.

2. Principle of Operation



The permanent magnet generator provides power for excitation of the exciter field via the AVR which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived, usually via the isolating transformer, from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter rotor winding.

The simple control principle described above hides the complexity of the electronic AVR which drives it. The AVR senses true rms voltage on three phases ensuring close regulation even with a generator output distorted by non-linear load e.g. thyristor controlled DC drive. In addition it detects engine speed and provides variable levels of voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine.

It also provides over-excitation protection during fault conditions, and over-voltage protection, with provision for operating an external circuit breaker and additional adjustable elements are incorporated to shape and optimise the heavy load switching capability of the generating set, by varying the generator performance during load switching to match the engine performance.

The detailed function of the AVR circuits and their adjustment are covered in the load testing section in the respective AVR manual.

In addition, the AVR incorporates circuits which, when used in conjunction with accessories, can provide for parallel operation either with ’droop’ or ’astatic’ control and VAr / PF control, during parallel operation.

Function and adjustment of the accessories which can be fitted inside the generator terminal box are covered in the accessories section of this manual.

Separate instructions are provided with other accessories available for control panel mounting.

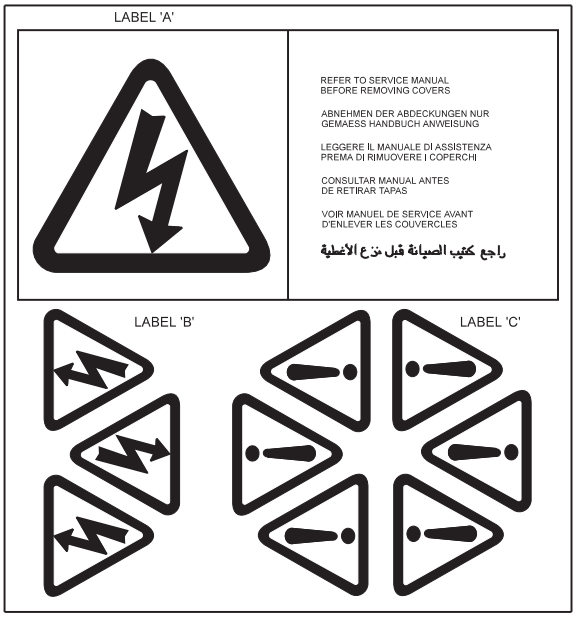
3. Application of the Generator

Warning Labels

Warning labels are affixed to the generator. These must be visible at all times.

As we expect the set builder to paint the generator in his own livery, a second set of labels can be found in a wallet attached to the generator. Use the labels as per the instructions printed on the reverse of the labels.

NOTE: If removed or painted over, it is the genset manufacturer's responsibility to reaffix warning symbols onto the generator



The ambient conditions in which a generator is operated or stored should be fully understood, to ensure the generator is maintained in a fully serviceable condition. Areas for consideration include temperature, humidity and even vibration levels. Temperatures should be stable, but if combined with high humidity levels, anti-condensation heaters should be connected to a suitable single phase mains supply. Within the generator's storage or installed area, thermostatic control of space heaters will be of considerable assistance.

If the generator is subjected to conditions which result in condensation forming within the generator, steps must be taken to ventilate and heat the generator. The winding insulation resistance must be measured and be above the minimum values stated in section 4.4.1 of this book before the generator is put into service.

Generator bearings which are not rotating but are subject to vibration frequently become damaged by the occurrence of indentations on the race ways at rolling element spacing. Although the loads involved are considerably less than the static load needed to produce an indentation, the lack of a lubrication film will allow localised corrosion to occur. This phenomenon is known as False Brinelling. This type of damage can be caused as the machine is transported, for example rail transport commonly subjects the bearing to this type of vibratory loading. To minimise the effects of false Brinelling, the machines should be transported on an absorbent mat (damper).

During the transportation of the generator care must be taken to ensure that the machine is not subjected to any sudden impact loads. Lowering the generator by a crane too quickly will cause damage to the machine bearings. This has the effect of causing indentations at rolling element spacing on the bearing raceways. This type of damage is termed Brinelling.

Note: The machine has been fitted with a shock load vibration indicator. The device which is fitted inside the terminal box, will indicate whether or not the machine has been subjected to harmful levels of acceleration i.e. >15 g (the warranty will be void if removed).

As the machine is operating, subjecting the generator to imposed vibration that exceeds the recommended levels will reduce bearing life and cause damage to the structure of the machine.

The manufacturer will permit their machines to run up to a vibration limit of 18 mm/s rms to ISO 8525-9 conditions for standby applications. When the machine is used in a prime power application, if the levels of vibration are not reduced there is a risk of mean time before failure (MTBF) being reduced due to the effect vibration has on bearing life, lubrication life and wound component life. See ISO 10816-1:1995 referred to in ISO 8528-9, quoted below.

"Class IV: large prime movers and other large machines with rotating masses mounted on foundations which are relatively soft in the direction of the vibration measurements."

Zone C – starts at 7.1 mm/s rms – ends at 18 mm/s rms (N.B. Class IV gives highest readings.)

"Zone C machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action."

The axial vibration limit for single bearing machines operating continuously (prime power) is 6 mm/s rms. If this level is exceeded, corrective action must be taken: either reduce the level or fit a hardened NDE bearing cartridge.

Note: The manufacturer will not be held responsible for equipment failure due to incorrect specification at time of order.

The reader should consider, if the above recommendations are not complied with, the effect on bearing / grease life will be a considerable reduction. These effects are illustrated graphically in figure 3-3.

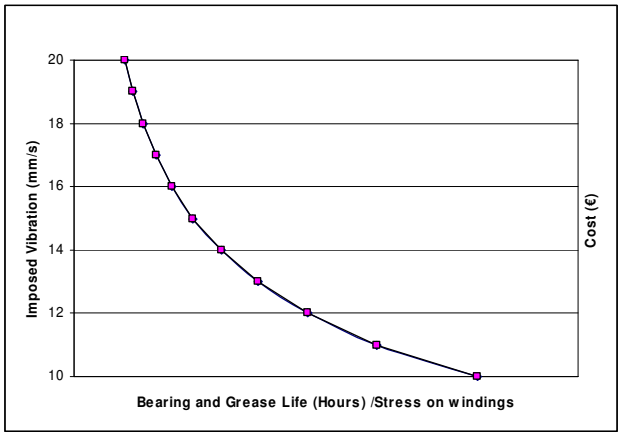


Figure 3-3

The generators have been designed for use in a maximum ambient temperature of 40°C in accordance with BS 5000.

Ambient temperatures in excess of 40°C can be tolerated with reduced ratings – refer to section 5.5 of this manual for further details.

The generators are of self-ventilated screen protected drip-proof design (IP23) and are not suitable for mounting outdoors unless adequately protected by the use of canopies. Anti-condensation heaters are recommended during storage and for standby duty to ensure winding insulation is maintained in good condition.

When installed in a closed canopy it must be ensured that the ambient temperature of the cooling air to the generator does not exceed that for which the generator has been rated.

The canopy should be designed such that the engine air intake to the canopy is separated from the generator intake, particularly where the radiator cooling fan is required to draw air into the canopy. In addition the generator air intake to the canopy should be designed such that the ingress of moisture is prohibited, preferably by use of a two stage filter.

The air intake / outlet must be suitable for the air flow given in the following table with additional pressure drops less than or equal to those given in table 3-1

Frame	Air Flow		Additional (intake/outlet) Pressure Drop
	50 Hz	60 Hz	
P80 (R, S, T)	3.2 m^3/sec (5297 cfm)	3.7 m^3/sec (627 cfm)	13 mm water gauge
P80 (W, X, Y)	4.0 m^3/s (8496 cfm)	4.7 m^3/s (9960 cfm)	13 mm water gauge

Table 3-1

Important! **Reduction in cooling air flow or inadequate protection to the generator can result in damage and / or failure of windings. If air filters are fitted, a differential pressure switch or alarm must be fitted to limit changes in air flow or pressure.**

Dynamic balancing of the generator rotor assembly has been carried out during manufacture in accordance with BS 6861 Part 1 Grade 2.5 to ensure vibration limits of the generator are in accordance with BS 4999 Part 142.

The main vibration frequencies produced by the generator are as follows:

4 pole	1500 rpm	25 Hz
4 pole	1800 rpm	30 Hz

However, vibrations induced by the engine are complex and contain frequencies of 1.0, 1.5, 2.0 or more times the fundamental frequency of vibration. These induced vibrations can result in generator vibration levels higher than those derived from the generator itself. It is the responsibility of the generating set designer to ensure that the alignment and stiffness of the bedplate and mountings are such that the vibration limits of BS 5000 Part 3 are not exceeded.

In standby applications where the running time is limited and reduced life expectancy is accepted, higher levels than specified in BS 5000 can be tolerated, up to a maximum of 18 mm/sec.

Two bearing generators require a substantial bedplate with engine / generator mounting pads to ensure a good base for accurate alignment. Close coupling of engine to generator can increase the overall rigidity of the set. For the purposes of establishing set design the bending moment at the engine flywheel housing to generator adaptor interface should not exceed 275 kgm (2000 ft lbs). A flexible coupling, designed to suit the specific engine / generator combination, is recommended to minimise torsional effects.

Alignment of single bearing generators is critical and vibration can occur due to the flexing of the flanges between the engine and generator. As far as the generator is concerned, the maximum bending moment at this point must not exceed 275 kgm (2000 lbs ft).

Single bearing generators require a substantial bedplate with engine / generator mounting pads to ensure a good base for accurate alignment.

The maximum bending moment of the engine flange must be checked with the engine manufacturer.

Torsional vibrations occur in all engine-driven shaft systems and may be of a magnitude to cause damage at certain critical speeds. It is therefore necessary to consider the torsional vibration effect on the generator shaft and couplings.

It is the responsibility of the generator set manufacturer to ensure compatibility, and for this purpose drawings showing the shaft dimensions and rotor inertias are available for customers to forward to the engine supplier. In the case of single bearing generators coupling details are included.

Important! **Torsional incompatibility and / or excessive vibration levels can cause damage or failure of generator and / or engine components.**

The standard build terminal box arrangement is for cable entry into the left hand side of the terminal box when viewed from generator D. E. Cable entry from the right hand side is possible if specified at the time of order.

The terminal box is constructed with a removable panel for easy adaptation to suit specific glanding requirements. Within the terminal box there are insulated terminals for line and neutral connections and provision for earthing. The neutral is NOT connected to the frame.

Danger!

No earth connections are made on the generator. Refer to site regulations for earthing. Incorrect earthing or protection arrangements can result in personal injury or death.

The main stator winding has six leads brought out to terminals in the terminal box. The three leads brought to the neutral terminal have been arranged to allow for the provision of differential protection using specific current transformers supplied by the manufacturer.

If it becomes necessary for customers to use current transformers not supplied by their manufacturer, these should be fitted by competent technicians with particular care being taken to ensure the cables are positioned centrally within the current transformer opening. The generator AVR incorporates protection circuits which operate on overload or fault conditions.

If a detected abnormal condition still exists after 8 seconds the AVR de-excites the generator causing a collapse in output voltage. This de-excitation may be as a result of an electronic solid state protection circuit, or the AVR tripping the excitation circuit breaker. The latter, if fitted, would be located adjacent to the AVR.

To reset the AVR trip circuits it is necessary to stop the engine – generator. The AVR solid state trip circuits will automatically reset after the generator has been stationary for 3 seconds. The excitation trip circuit breaker needs to be manually reset if fitted. The system designer should ensure that these AVR functions are compatible with the overall system protection.

Fault current curves (decrement curves), together with generator reactance data, are available on request to assist the system designer to select circuit breakers, calculate fault currents and ensure discrimination within the load network.

This instruction book must be read before incorporation of the generator into a generating set. Maintenance must be carried out with the generating set out of service and precautions taken to avoid accidental starting of the generator set.

Warning!

If smoke or unexpected sounds are being emitted from the machine, shut the machine down immediately. DO NOT go to the machine to investigate whilst it is running.

Danger!

Incorrect installation, service or replacement of parts can result in severe personal injury or death and / or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.

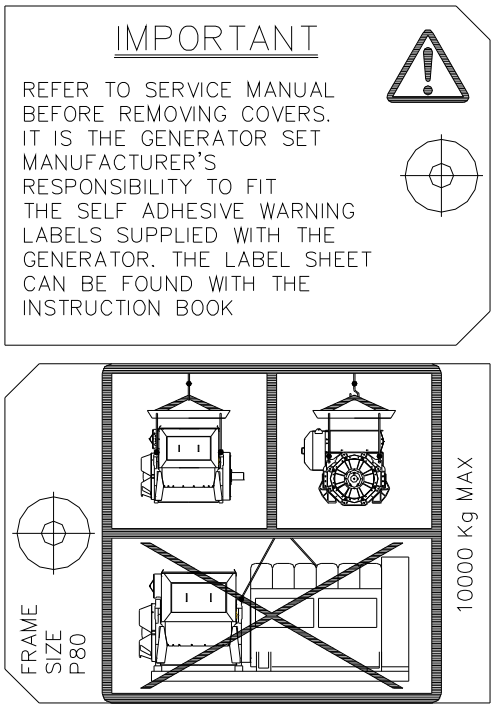
4. Installation – Part 1

4.1. Lifting

Warning!

Incorrect lifting can result in severe personal injury or equipment damage. Lifting capacity required for complete generator is 10 tonnes. See data sheets for weights of individual lifts. Generator lifting lugs should not be used for lifting the complete generating set.

Four lifting lugs are provided for use with a shackle and pin type lifting aid in conjunction with a spreader bar. Chains of suitable length and lifting capacity must be used. Care is therefore needed to avoid personal injury or equipment damage. Correct lifting arrangement is shown on the label attached to a lifting eye. A typical label is shown below.


IMPORTANT
REFER TO SERVICE MANUAL BEFORE REMOVING COVERS. IT IS THE GENERATOR SET MANUFACTURER'S RESPONSIBILITY TO FIT THE SELF ADHESIVE WARNING LABELS SUPPLIED WITH THE GENERATOR. THE LABEL SHEET CAN BE FOUND WITH THE INSTRUCTION BOOK
FRAME SIZE P80
10000 Kg MAX

Single bearing generators are supplied with the rotor clamped to the DE bracket with a transit strap to prevent axial movement of the rotor and a support bracket has been fitted which supports the rotor under the fan hub. Once this strap is removed to couple the rotor to the engine, the rotor is free to move in the stator, and care is needed during coupling and alignment to ensure the frame is kept in the horizontal plane.

4.2. Installation with engine (factory / on site)

Before the generator can be installed, suitable mounting conditions must first exist. Failure to comply with the following will result in structural damage to the generator and premature bearing failure. The following guidelines must be observed:

- There must be an adequate foundation under genset taking into consideration sub-soil conditions loading thereon. In cases where the soil conditions include clay or permafrost, extra provision needs to be given to the design of the foundation to ensure the rigidity / stability of the mounting surface.
- If adjustable height AVMs are fitted, the flatness of the floor must be within 10 mm under the genset floor profile.
- If non-adjustable AVMs are fitted, the flatness of the floor must be within 3 mm under the genset floor profile.
- If the generator is mounted directly on to a skid (no AVM interface), the flatness all four generator feet mounts must be within 0.25 mm. Use shims to achieve the required level of the generator.
- The skid / AVM arrangement must be suitably supportive so that the relative operation motion between the generator and the engine is minimal.

Note: If non-adjustable AVMs are fitted, only a foundation with specially levelled concrete with steel screeding bars will suffice. No joints or expansion joints in a floor must pass under a genset.

4.2.1. Two bearing machines

Note: Failure to comply with this procedure may void warranty claims.

A flexible coupling should be fitted and aligned in accordance with the coupling manufacturer's instruction.

If a close coupling adaptor is used the alignment of machined faces must be checked by offering the generator up to the engine. Shim the generator feet if necessary. Ensure adaptor guards are fitted after generator / engine assembly is complete.

If the assembly procedures do not permit the alignment to be measured it is possible that the load imposed on the DE bearing will be increased to an unacceptable level. To overcome the effect of unmeasured misalignment on the bearing, (caused by coupling stiffness and time related rubber degradation / hardening) it is recommended that a larger load capacity bearing be fitted. This option will regain the expected bearing L_{10} life and can be purchased from the Company. The re-greasing interval of this type of bearing is shorter than a standard ball bearing. Automatic re-greasing equipment can also be purchased from the Company.

In instances where the alternator is coupled via a gearbox or to a steam or gas turbine, thermal growth must be taken into alignment consideration. The Company recommends that the alignment is set cold with growth taken into consideration and then checked hot for good alignment.

Note: The Company will not be held responsible for equipment failure due to incorrect specification at the time of order.

Prime Power only:
Where machines are subjected to vibration levels over 10 mm/s rms (measured at the ISO bearing positions), the factory recommends that roller bearings be fitted because they have a larger load capacity. These bearings can be purchased from your local distributor. The re-greasing interval of this

type of bearing is shorter that a standard ball bearing. Automatic re-greasing equipment can also be purchased from your local distributor.

Note: Failure to comply with these recommendations may void warranty claims.

Open coupled sets require a suitable guard, to be provided by the set builder.

Caution! Incorrect guarding and / or generator alignment can result in personal injury and / or equipment damage.

4.2.2. Single bearing machines

4.2.2.1. Generator assembly

All generators are transported from the factory with a shaft-locking strap fitted across the outside of the fan housing. Premature removal of this strap will result in damage to the air gap surfaces of the exciter, fitted inboard of the non-drive end bearing. So that the locking strap can be safely removed, a shaft support bracket has been fitted which supports the rotor underneath the fan hub. It is essential that the support bracket is removed before the machine is run.

Before removing the strap and support bracket, the following steps must be followed:

- Once the generator is on site and positioned close to its final position, remove the shaft locking strap fitted across the font of the shaft.
- Couple the generator to the engine.

Note: The rotor support bracket has not been designed so that the generator can be barred over. Under no circumstances must the generator be barred over using the fan. The engine should be turned over instead.

- It is only safe to remove the support bracket when all the engine / generator-coupling bolts have been fully tightened. This is done by removing the two bolts in the support bracket and pulling it forward to clear the mounting face. Finally withdraw it through one of the side openings.

4.2.2.2. Alignment

Alignment of single bearing generators is critical. If necessary, shim the generator feet to ensure alignment of the machined mounting surfaces.

The sequence of assembly to the engine should generally be as follows:

- On the engine check the distance from the coupling mating face on the flywheel to the flywheel housing mating face. This should be within 0.5 mm of nominal dimension. This is necessary to ensure that a thrust is not applied to the AC generator bearing or engine bearing.
- Check that the bolts securing the flexible plates to the coupling hub are tight and locked into position. For tightening torque refer to Maintenance Manual section 7, Table 7-3.
- Remove covers from the drive end of the generator to gain access to coupling and adaptor bolts.
- Check that coupling discs are concentric with adaptor spigot. This can be adjusted by suspending the rotor by a soft sling of suitable SWL which passes through the adaptor opening.
- Offer the AC generator to the engine and engage both coupling discs and housing spigots at the same time, finally pulling home by using the housing and coupling bolts. Use heavy gauge washers under the heads of the coupling disc to flywheel bolts.

- Tighten coupling disc to flywheel bolts. Refer to engine manual for torque setting of disc to flywheel bolts.
- Replace covers. Check for excessive vibration at the time of initial run-up.

Note: Failure to comply with these recommendations may void warranty claims.

Danger!

Incorrect guarding and / or generator alignment can result in personal injury and / or equipment damage.

4.3. Earthing

The generator frame should be solidly bonded to the generating set bedplate. There is an earth point in each foot – see figure 4-1. If anti-vibration mounts are fitted between the generator frame and its bedplate, a suitably rated earth conductor (normally one half of the cross sectional area of the main line cables) should bridge across the anti-vibration mount.

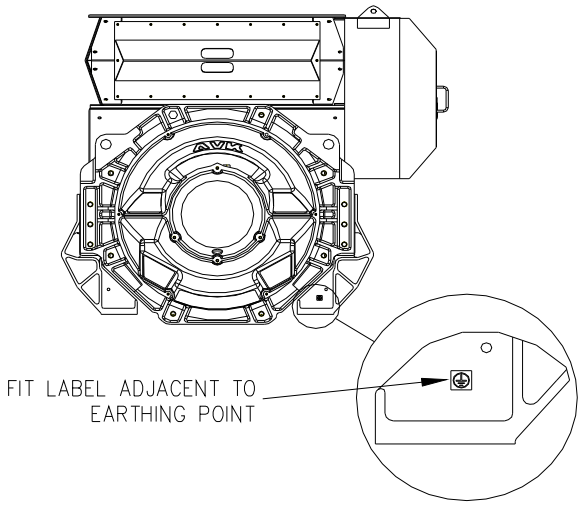


Figure 4-1

There is also an additional earth inside the terminal box which should be used to provide equipotential bonding.

Note: The main earth point for MV and HV machines is foot position; and on LV machines the main earth point is inside the terminal box.

4.4. Pre-running checks

Caution! **Refer to local regulation to ensure that the correct earthing procedure has been followed.**

4.4.1. Insulation checks

Before starting the generating set after completing assembly, test the insulation resistance of the main stator windings.

It should be noted that as winding temperature increases values of insulation resistance will significantly reduce. Therefore true values of insulation resistance should be established with windings at ambient temperatures.

Caution! **The AVR plus any voltage transformers should be disconnected, and any temperature detector leads (RTDs / Thermistors) grounded during the test. Refer to the generator wiring diagram for details.**

4.4.1.1. LV generators

A 1000V megger or similar instrument should be used. Disconnect any earthing conductor connected between neutral and earth and megger an output lead terminal U, V or W to earth. The 1 minute insulation resistance reading for the total winding should be in excess of 10 MΩ to earth. Should the insulation resistance be less than 10 MΩ the winding must be dried out as detailed in the Service and Maintenance section of this manual.

4.4.1.2. MV generators

A 2500V motorised megger or similar instrument should be used. Separate the three netural leads, ground V and W leads and megger U to ground. Repeat for V phase with U and W grounded and W phase with U and V grounded. The 1 minute insulation resistance for each phase should not be less than 100 MΩ and the polarisation index should be in the order of 2 or greater and 20 ºC.
($PI = IR_{10min} / IR_{1min}$)

If these values cannot be achieved, the winding should be dried out as detailed in the Service and Maintenance section of this manual.

Danger!

Short stator terminals to earth with an earthing rod after IR and HV testing, for at least 5 minutes to discharge windings.

4.4.1.3. HV generators

A 5000V motorised megger or similar instrument should be used. Separate the three neutral leads, ground V an dW leads and megger U to ground. Repeat for V phase with U and W grounded and W phase with U and V grounded. The 1 minute insulation resistance for each phase should not be less than 300 MΩ and the polarisation index should be in the order of 2 or greater at 20 ºC.
(PI = IR_{10min} / IR_{1min})

If these values cannot be achieved, the winding should be dried out as detailed in the Service and Maintenance section of this manual.

Danger!

Short stator terminals to earth with an earthing rod after IR and HV testing, for at least 5 minutes to discharge windings.

4.4.2. Direction of rotation

Standard machines are fitted with a backward inclined radial bladed fan and therefore only suitable for running in one direction of rotation. The generator is supplied to give a phase sequence of U V W with the generator running clockwise looking at the drive end (unless otherwise specified at the time of ordering). If the generator phase rotation has to be reversed after the generator has been despatched apply to factory for appropriate wiring diagrams.

4.4.3. Voltage and frequency

Check that the voltage and frequency levels required for the generating set application are within the range indicated on the generator nameplate.

4.4.4. AVR settings

Refer to attached leaflet for setting up procedures to AVR equipment.

4.5. Test metering / cabling

Warning!

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components.

Only personnel qualified to perform electrical service should carry out testing and / or adjustments

Connect any instrument wiring and cabling required for initial test purposes with permanent or spring-clip type connectors.

Minimum instrumentation for testing should be line to line or line to neutral voltmeter, Hz meter, load current metering and kW meter. If reactive load is used a power factor meter is desirable.

Important! **When fitting power cables for load testing purposes, ensure cable voltage rating is at least equal to the generator rated voltage. Support the cables to prevent side load on the terminal.**

The load cable termination should be placed on top of the winding lead termination and clamped between the two nuts provided, as in figure 4-2.

Note: For torque setting value, see Maintenance Manual section 1.

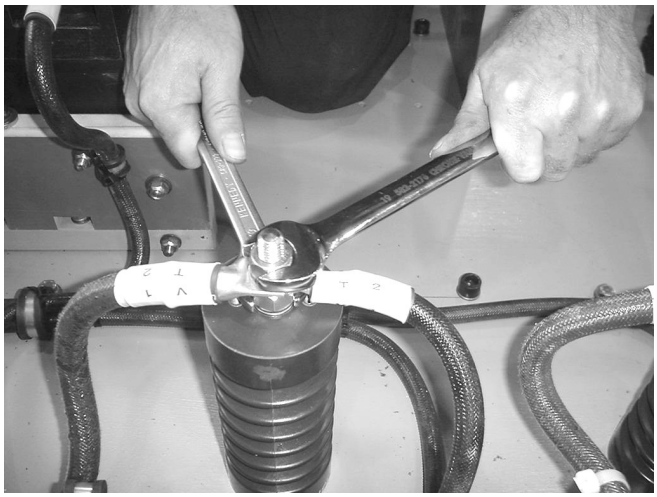


Figure 4-2

4.6. Accessories

If there are accessories for control panel mounting supplied with the generator refer to the specific accessory fitting procedures inserted inside the back cover of this book.

Replace AVR access cover after all adjustments are completed.

5. Insulation – Part 2

5.1. General

The extent of site installation will depend upon the generating set build, e.g. if the generator is installed in a canopied set with integral switchboards and circuit breaker, on site installation will be limited to connecting up the site load to the generating set output terminals. In this case reference should be made to the generating set manufacturer's instruction book and any pertinent local regulations.

If the generator has been installed on a set without switchboard or circuit breaker the following points relating to connecting up the generator should be noted.

5.2. Glanding

The standard build terminal box arrangement is for cable entry into the right hand side of the terminal box when viewed from generator NDE with removable panel for ease adaptation to suit specific glanding requirements.

Incoming cables should be supported from either below or above the box level at a sufficient distance from the centre line of the generating set so as to avoid a tight radius at the point of entry into the terminal box panel, and allow movement of the generator set on its anti-vibration mountings without excessive stress on the cable. The generator should be free to move at least ±25 mm as per Figure 5-1.

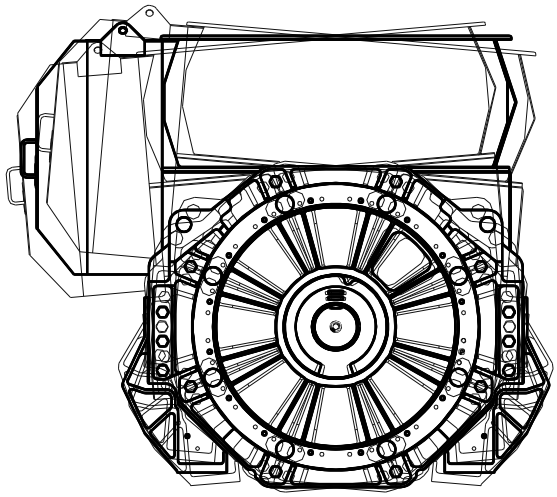


Figure 5-1

In addition the cable should be clamped at the gland so that forces on the cable due to set movement cannot be transmitted to the insulated terminals in the terminal box.

Before making final connections, test the insulation resistance of the windings. The AVR should be disconnected during this test and RTD leads grounded.

For the MAIN STATOR WINDINGS the following type of megger or similar instrument should be used.

LV generators: 1000V motorised instrument
MV generators: 2500V motorised instrument
HV generators: 5000V motorised instrument

The measured insulation resistance should be above the value stated in Table 5-1 taken at 1 minute.

GENERATOR TYPE		
LV	**MV**	**HV**
10 Meg Ohms	**100 Meg Ohms**	**300 Meg Ohms**

Table 5-1

If these values cannot be achieved the windings should be dried out as detailed in the Service and Maintenance section of this manual.

A 500V instrument is suitable for all other windings and a minimum insulation resistance value of 1 MΩ should be recorded.

5.2.1. Connections on MV and HV generators

When making connections to the insulated terminals the incoming cable termination should be placed on top of the winding lead termination(s) and clamped between the two nuts provided as shown in Figure 5-2.

Note: For torque setting value see Maintenance manual section 1.

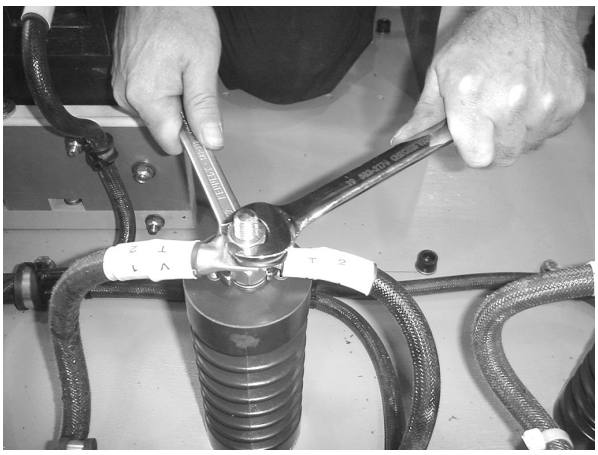


Figure 5-2

It is important to note that **all** the cable lugs at the connection point are mounted palm to palm as shown in Figure 5-3. The lugs must not be separated by a nut as the stud will then have to carry the full rated current.

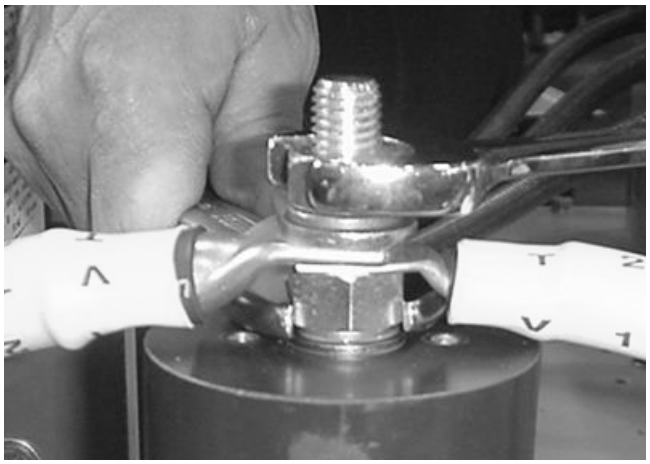


Figure 5-3

5.2.2. Connections on LV generators

When making connections directly on to the busbars, the incoming cable termination should be made by directly placing the palm of the lug either on the top or bottom surface of the busbar. The screws used should be M12 grade 8.8 and tightened to a torque of 80 Nm.

Note: Figure 5-4 shows a two hole lug termination on top of the busbar, but terminations can be made top / bottom with one or two hole lugs (the torque setting remains the same). The type of termination must be specified at the time of order so that the correct busbar configuration can be supplied.

Figure 5-4

Caution! **The load cables must not be connected via any rigid right-angled extension bar to the main terminals.**
This will cause excessive side loads on the cast resin insulation

Important! **To avoid the possibility of swarf entering any electrical components in the terminal box, panels must be removed for drilling.**

5.3. Earthing

The neutral of the generator is not bonded to the generator frame as supplied from the factory. An earth terminal is provided inside the terminal box adjacent to the main terminals. Should it be required to operate with the neutral earthed a substantial earth conductor **(normally equivalent to one half of the section of a line conductor)** must be connected between the neutral and the earth terminal inside the terminal box. The generator feet should be already bonded to the generating set bedplate by the generating set builder, and will normally be required to be connected to the site earth system.

Caution! Reference to local electricity regulations or safety rules should be made to ensure correct earthing procedures have been followed.

5.4. Protection

Although the AVR incorporates certain protective elements as already described, it is the responsibility of the end user and his contractors / sub-contractors to ensure that the overall system protection meets the needs of any inspectorate, local electricity authority or safety rules, pertaining to the site location.

High voltage transient surges generated by a switching device or lightning strikes on overhead cables must be prevented from reaching the generator terminals by the fitting of correctly designed surge suppression devices. These must be connected as close to the generator terminals as practicable, and ideally consist of surge arresters and surge capacitors.

A separate publication entitled Application Guidelines, covers this topic more fully and is available on request.

Where generators are connected to overhead transmission lines either directly or via transformers, the overhead lines should be fitted with surge arresters to reduce surge levels on the more immediate generator protection. Overhead line arresters should ideally be at a distance of 350 m from the generator.

To enable the system designer to achieve the necessary protection and / or discrimination, fault current curves are available on request from the factory, together with generator reactance values to enable fault current calculations to be made.

On LV generators the star point busbars arrangement allows for the fitting of differential protection current transformers.

Provision has been made for an earth leakage detection current transformer which is positioned between the star point and neutral terminal.

On MV and HV generators the main stator winding has six leads brought out to terminals in the terminal box. The three leads brought to the neutral terminal have been arranged to allow for the provision of differential protection with the option of clamps and mounting plates for specific current transformers supplied by the Company.

If it becomes necessary for customers to use current transformers not of authorised supply, these should be fitted in an engineered manner with particular care being taken to ensure the cables are positioned centrally within the current transformer opening and the CT selected will survive the imposed vibration.

Generator output terminals can be offered in an arrangement to suit the fitting of specific DIFFERENTIAL PROTECTION current transformers supplied by your local distributor. This requirement should be specified at time of order.

5.5. Commissioning

Ensure that all external cabling is correct, permits adequate movement and that all the generating set manufacturer's pre-running checks have been carried out before starting the set.

The generator AVR controls will have been adjusted during the generating set manufacturer's tests and should normally not require further adjustment.

Protection of enclosures and structures

Before the machine is run, all removable panels must be replaced and all fasteners securely tightened. Failure to do this will result in damage to the structure of the machine.

Should malfunction occur during commissioning refer to Service and Maintenance manual, "Fault Finding" section.

Bearing protection

Bearing RTD settings (if fitted) for single end ventilated machines only. The bearing RTDs are mounted in a ring terminal at the front of the bearing cartridge. These RTDs are designed to monitor changes in bearing temperature. Since the ambient air temperature will vary, the recommended limits given are for a 40 ºC ambient – see Table 5-2 (for higher ambient temperatures increase the following values proportionally up to a maximum of 50 ºC). For lower ambients these settings should be reduces accordingly.

Note: The NDE bearing typically runs 25 ºC cooler than the DE.

Bearing type	Alarm temperature ºC	Shutdown temperature ºC
DE bearing	85	90
NDE bearing	60	65

Table 5-2

Note: Failure to shut the machine down on alarm and immediate investigation will result in bearing failure and the likelihood of severe damage to rotor and stator bore or even the complete destruction of the equipment. Upon alarm the immediate reaction should be to re-grease the bearing and monitor the temperature to see if the temperature resets. The machine should be shutdown at the first opportunity for examination. If the alarm does not reset, shut the machine down IMMEDIATELY. Severe bearing failure is also indicated by noise, smoke and excessive vibration. Re-greasing will not alleviate this situation. For further protection, the Company recommend bearing monitoring using Shock Pulse technology, either as a routine maintenance procedure or fixed installation.

Stator protection (RTD settings)

The machine is designed to run in a 40 ºC ambient at full rated load at 0.8 power factor. However, to avoid damage to the machine the stator protection RTDs must be set correctly.

To set the alarm and shutdown values the machine must first be running at full rated load and 0.8 power factor with the temperature rise having reached the peak value (typically after 3 -4 hours).

The value at which the alarm setting is set must be calculation using the following equation:

$$T_1 = \Delta T + (40 - T_{ambient\ max.}) + 5\ (^{o}C)$$

T_1 = Alarm setting (ºC)
ΔT = Stator temperature rise (ºC)
(Actual RTD value – ambient temperature)
$T_{ambient\ max.}$ = Maximum site ambient temperature (ºC)

Note: The maximum site ambient temperature is not necessarily the temperature at the time of setting.

The value at which the shutdown setting is set must be calculated as follows:

$$T_2 = T_1 + 10\ (^{o}C)$$

The temperature at which the alarm and shutdown value are set is dependant on the insulation calss of the machine – see the label on the machine for the class details.

The actual values that the RTDs are set to **must not** exceed the levels specified in Table 5-3 if damage to the machine is to be prevented. If the ambient temperature exceeds 40 ºC or the site altitude exceeds 1000 m then the machine will need to be de-rated if the specified maximum setting values are not to be exceeded – Stamford Application Guidelines, section 1.1.

It should be noted that whilst the stator RTDs protect the stator winding, the prescribed setting system also protects the rotor winding which in some instances has the controlling influence.

Insulation Class	Alarm – T_1 ºC	Shutdown – T_2 ºC
B	120	140
F	145	165
H	170	190

Table 5-3

If it is not possible to achieve the above, contact the factory for advice before further running.

Changes to the machine enclosure (IP) rating:
It is important to note that the machine rating is affected by the design of the air inlet / outlet arrangement. Therefore, if the machine is modified in any way, the above will have to be reviewed – contact the factory for advice.

6. Accessories

6.1. General

Generator control accessories may be fitted, as an option. If fitted at the time of supply, the wiring diagram(s) in the back of this book shows the connections. When the options are supplied separately, fitting instructions are provided with the accessory.

Available accessories for generator mounting are as follows:

- Quadrature droop current transformer;
- VAr/PF controller and associate current transformers;
- Fault level limiting current transformers.

There are two terminal box mounted accessories, which relate to parallel operation i.e. DROOP and VAr/PF controller (see paragraph 6.2 and 6.5 respectively). Understanding of the following notes on parallel operation is essential before attempting the fitting or setting of either accessory.

When operating in parallel with other generators or the mains, it is essential that the phase sequence of the incoming generator matches that of the busbar and also that all of the following conditions are met before the circuit breaker of the incoming generator is closed on to the busbar (or operational generator).

- Frequency must match within close limits.
- Voltages must match within close limits.
- Phase angle of voltages must match within close limits.

A variety of techniques, varying from simple synchronising lamps to fully automatic synchronisers, can be used to ensure these conditions are met.

Important! Failure to meet the above mentioned three conditions when closing the circuit breaker, will generate excessive mechanical and electrical stresses, resulting in equipment damage.

Once connected in parallel, a minimum instrumentation level per generator of voltmeter, ammeter, wattmeter (measuring total power per generator), and frequency meter is required in order to adjust the engine and generator controls to share kW in relation to engine ratings and kVAr in relation to generator ratings.

It is important to recognise that:

- True kW are derived from the engine, and speed governor characteristics determine the kW sharing between sets.

And

- kVAr are derived from the generator, and excitation control characteristics determine the kVAr sharing.

Reference should be made to the generating set manufacturer's instructions for setting the governor controls.

6.2. Droop

The most commonly used method of kVAr sharing is to create a generator voltage characteristic which falls with decreasing power factor (increasing kVAr). This is achieved with a current transformer (CT) which provides a signal dependent on current phase angle (i.e. power factor) to the AVR.

Note: If 'current limit' transformers are fitted the "W" phase CT provides both droop and current limit.

The current transformer has a burden resistor on the AVR board, and a percentage of the burden resistor voltage is summed into the AVR circuit. Increasing droop is obtained by turning the "DROOP" control potentiometer clockwise.

Figure 6-1 indicates the effect of droop in a simple two generator system. Generally 5% droop at full laod current zero pf is sufficient to ensure kVAr sharing.

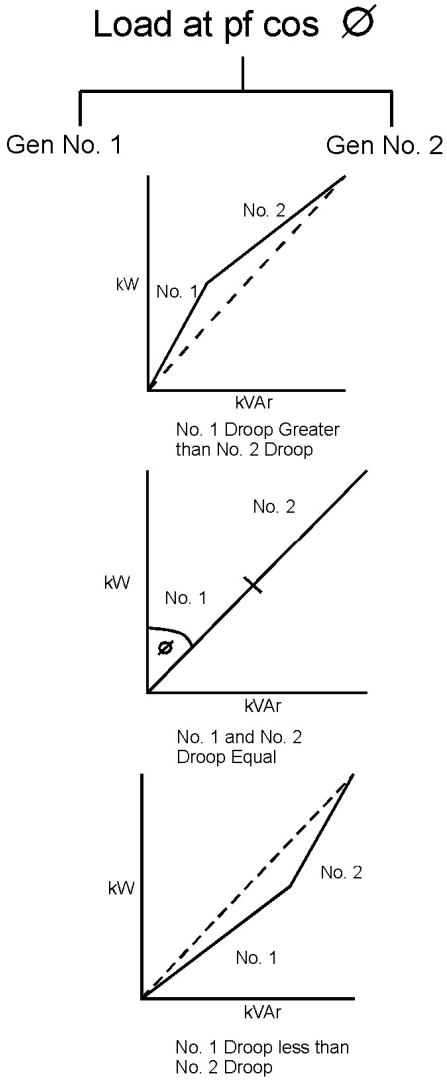


Figure 6-1

If the droop accessory has been supplied with the generator it will have been tested to ensure correct polarity and set to a nominal level of droop. The final level of droop will be set during generating set commissioning.

Setting procedure
Depending upon available load, the following settings should be used – all are based on rated current level.

Power factor Load	***Set droop to:***
0.8 pf (at full load current)	***3 %***
Zero pf (at full load current)	***5 %***

Setting the droop with low power factor load is the most accurate.

Run each generator as a single unit at rated frequency or rated frequency + 4% depending upon type of governor and nominal voltage. Apply available load to rated current of the generator. Adjust 'DROOP' control to give droop in line with above table. Clockwise rotation increases amount of droop.

Note 1: Reverse polarity of the CT will raise the generator voltage with load. The polarities S1-S2 shown on the wiring diagrams are correct for clockwise rotation of the generator looking at the drive end. Reversed rotation requires S1-S2 to be reversed.

Note 2: The most important aspect is to set all generators equal. The precise level of droop is less critical.

Note 3: A generator fitted with droop circuit, operated as a single unit at rated load 0.8 pf is unable to maintain the usual ± ½% regulation.

A shorting switch can be connected across S1-S2 to restore regulation for single running.

Important! **LOSS OF FUEL to an engine can cause its generator to motor with consequent damage to the generator windings.**

Reverse power relays should be fitted to trip main circuit breaker.

LOSS OF EXCITATION to the generator can result in large current oscillations with consequent damage to the generator windings. Excitation loss detection equipment should be fitted to trip main circuit breaker.

With the switch across K1-K2 open, start the generating set.

6.3. Power Factor Controller (PFC3)

This accessory is primarily designed for those generator applications where operation in parallel with the mains supply is required.

Protection against loss of mains voltage or generator excitation is not included in the unit and the system designer must incorporate suitable protection.

The electronic control unit requires both droop and kVAr current transformers. When supplied with the generator, wiring diagrams inside the back cover of this manual show the connections and the additional instruction leaflet provided gives details of setting procedures for the power factor controller (PFC3).

The unit monitors the power factor of the generator current and adjusts excitation to maintain the power factor constant. This mode can also be used to control the power factor of the mains if the point of current monitoring is moved to the mains cables. Refer to the factory for appropriate details.

It is also possible to operate the unit to control kVAr of the generator if required. Refer to the factory for appropriate details.

6.4. Machine upgrades

- Heaters: Anti-condensation heaters can be retro-fitted into the machine – refer to factory for details.
- RTDs: Bearing RTDs can be fitted onto the machine – refer to the factory for details.
- Current transformers: CTs can be fitted into the machine – refer to the factory for details.

Heaters connection

If the machine is supplied with heaters, the electrical supply has to be connected inside the auxiliary terminal box on the terminal rail – refer to the wiring diagram for the connection point numbers. The heaters can either be connected in series or parallel. For parallel connection, the supply voltage range is 100V – 138V and for series connection, the supply voltage range is 200V – 277V. See Figure 6-2 for details.

Note: If the heaters are connected in series a link will be needed between the appropriate terminals on terminal rail – refer to the machine wiring diagram on the inside of the lid of the auxiliary terminal box.

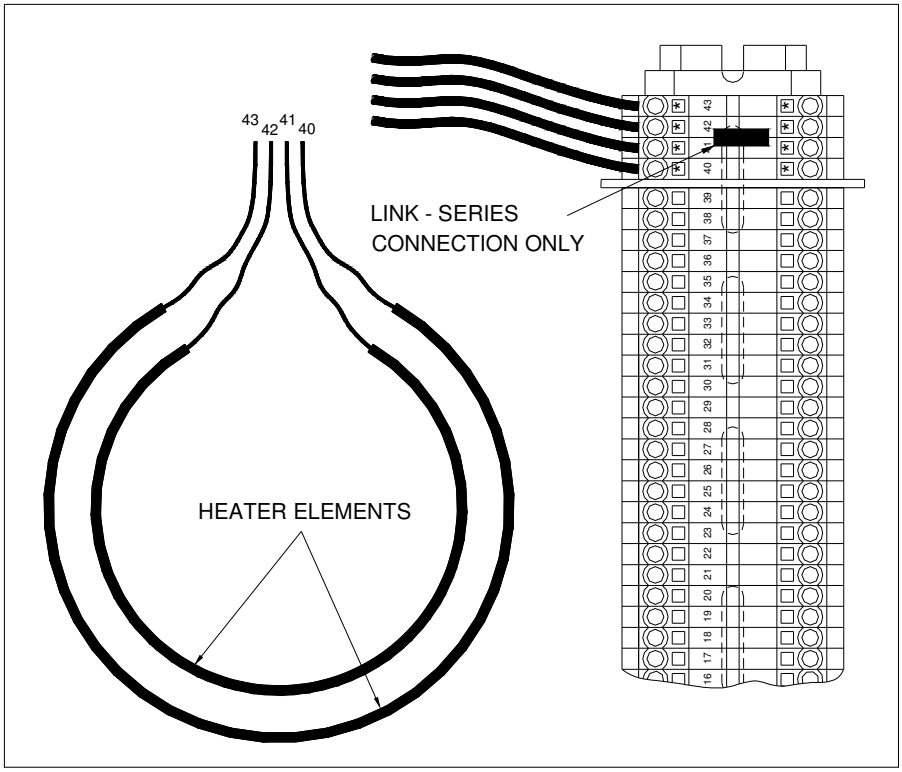


Figure 6-1

Note: the pin numbers used above are an example only

7. Service and Maintenance

Warning!

Service and fault finding procedures present hazards which can result in severe personal injury or death. Only competent personnel qualified to perform electrical and mechanical service, and who are familiar with the systems to be worked on, should carry out these procedures. Ensure all prime mover starting circuits are disabled and that any source of potential energy is isolated and locked out before commencing service or maintenance procedures. Isolate any anti-condensation heater supply.

As part of routine maintenance procedures, periodic attention to winding condition (particularly when generators have been idle for a long period) and bearings is recommended. (Refer to subsections 1.1, 1.2 and 1.4 respectively).

Danger!

Insulation testing leaves a high voltage.

Discharge windings by shorting to earth through an earthing rod, for at least 5 minutes, after testing.

Warning!

Incorrect lifting or inadequate lifting capacity can result in severe personal injury or equipment damage. Lifting capacity required for complete generator is 10 tonnes.

Warning!

See data sheet for weights of individual lifts. Generator lifting lugs should not be used for lifting the complete generating set.

7.1. Initial winding condition

The initial condition of the windings should be assessed both visually and by measurement of insulation resistance to earth using a 500V megger.

Care should be taken when dealing with windings which are suspected of being excessively damp or dirty. The initial measurement of insulation resistance should be established using a low voltage (500V) megger type instrument and if manually powered the handle should initially be turned slowly.

Full voltage megger tests or any other form of high voltage test should not be applied until the windings have been dried out and if necessary, cleaned.

Caution! **The AVR plus any voltage transformers should be disconnected. Any temperature detector devices (RTDs / Thermistors) should be disconnected and grounded during the test.**

Refer to the generator winding diagram for details.

Important! **The windings have been HV tested during manufacture and further HV testing may degrade the insulation with consequent reduction in operating life. Should it be necessary to demonstrate HV testing, for customer acceptance, the tests must be carried out at reduced voltage levels i.e. Test Voltage = 0.8 (2 x Rated Voltage + 1000). This applies only to new machines. After being in service, testing levels should be further reduced to 1.5 x Rated Voltage for maintenance testing. This HV test should only be completed after megger tests and evaluation.**

The insulation resistance values quoted are for windings at an ambient temperature of 20 ºC. It should be noted that as winding temperature increases, values of insulation resistance will significantly reduce. Therefore, the reference values for insulation resistance can only be properly established with windings at a temperature of approximately 20 ºC.

An appropriate guide to allow comparison with values taken at other temperatures is to assume that the IR reduces by 50% for every 10 ºC increases in temperature. Thus the reduction factors are:

20 ºC	x	1.0
30 ºC	x	0.5
40 ºC	x	0.25
50 ºC	x	0.125
60 ºC	x	0.625
70 ºC	x	0.313
80 ºC	x	0.015 etc.

Should the values be less than the quoted limits, drying out the generator windings is essential.

Auxiliaries

(PMG, exciter stator, exciter rotor with diode carrier and main rotor).

A 500V megger or similar instrument should be used. Minimum acceptable values after 1 minute are:

	New machine	In-service machine
PMG	5 MΩ	3 MΩ
Exciter stator	10 MΩ	5 MΩ
Combined rotor	200 MΩ	100 MΩ

Any drying out required can be done at the same time as the main stator.

LV generator stators

A 1000V megger or similar instrument should be used. Disconnect any earthing conductor connected between neutral and earth and megger an output lead terminal U, V or W to earth. Minimum acceptable limits after 1 minute for the total winding are:

New machine	In-service machine
10 MΩ	5 MΩ

Should the insulation resistance be less than specified, the winding must be dried out as below.

MV generator stators

A 2500V motorised megger or similar instrument should be used. Separate the three neutral leads, ground V and W leads and megger U to ground. Repeat for V phase with U and W grounded and W phase with U and V grounded. Minimum acceptable limits after 1 minute for each phase are:

New machine	In-service machine
100 MΩ	50 MΩ

The insulation resistance should not be less than specified and the polarisation index should be in the order of 2 or greater at 20 ºC.

($PI = IR_{10min} / IR_{1min}$)

If these values cannot be achieved the winding should be dried out as detailed in section 1.1.5.

Danger!

Short stator terminals to earth with an earthing rod after IR and HV testing, for at least 5 minutes to discharge windings.

HV generator stators

A 5000V motorised megger or similar instrument should be used. Separate the three neutral leads, ground V and W leads and megger U to ground. Repeat for V phase with U and W grounded and W phase with U and V grounded. Minimum acceptable limits after 1 minute for each phase are:

New machine	In-service machine
300 MΩ	150 MΩ

The insulation resistance should not be less than specified and the polarisation index should be in the order of 2 or greater at 20 ºC.

($PI = IR_{10min} / IR_{1min}$)

If these values cannot be achieved the winding should be dried out as detailed in section 1.1.5.

Danger!

Short stator terminals to earth with an earthing rod after IR and HV testing, for at least 5 minutes to discharge windings.

Drying out procedure

Danger!

This should only be undertaken by qualified experience personnel.

Drying out may be carried out by directing warm air from a fan heater or similar apparatus into the generator air inlets and / or outlets. Caution – take care not to scorch or over heat the windings by applying a high localised heat source. Running the machine unexcited is also beneficial for surface moisture removal.

Alternatively, the alternator main stator windings may be short circuited with a bolted 3 phase short at the main terminals and the generating set run with the **AVR disconnected** at terminals F1 and F2. A separate DC supply is connected to the exciter stator leads F1 and F2 (F1 must be connected to the positive of the DC supply and F2 to the negative of the DC supply). The DC supply must be variable from 0 – 24V and capable of supplying 1.0 amp. An AC current clip-on ammeter or similar instrument is required to measure the main stator winding current.

Set the DC supply voltage to zero. Start the generating set and slowly increase the DC voltage to pass current through the main stator winding. The current level should not exceed the rated current of the generator.

Note: Some winding designs may produce a voltage between the 3 shorted line terminals and the neutral.

Danger!

Risk of electric shock – do not touch line or neutral terminals during the short circuit run.

During drying, air must be able to flow freely through the generator in order to carry off the moisture.

Important! **The short circuit must not be applied with the AVR connected in circuit. Current in excess of the rated generator current will cause damage to the windings.**

The rate of rise of winding temperature should be limited to between 5 – 6 ºC per hour to prevent damage as water / water vapour is expelled from the insulation. The maximum recommended winding temperature is 85 / 90 ºC in order to avoid boiling (at 100 ºC). If fitted, winding RTDs can be used to monitor the winding temperature. (The standard platinum Pt100 RTD has a resistance of 107.7 Ω at 20 ºC increasing to 132.7 Ω at 85 ºC and to 138.5 Ω at 100 ºC).

Example: A main stator winding at an initial temperature of 20 ºC will take a minimum of 12 hours to rise to 90 ºC and then could take a further 24 to 48 hours to complete the drying process satisfactorily.

During drying, the resistance should be measured at regular intervals, typically every 15 minutes and a graph plotted of insulation resistance against time. The shape of the resulting curve will be similar to figure 1-1 below.

Figure 1-1 illustrates a typical curve for a generator which has absorbed a considerable amount of moisture. The curve indicates a temporary increase in resistance, a fall, and then a gradual rise to a steady figure. If windings are not very damp the dotted portion of the curve may not appear.

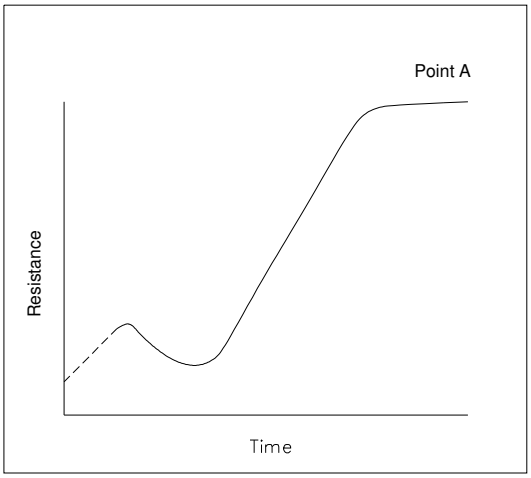


Figure 1-1

Drying should be continued after point “A” has been reached for at least one hour.

Once the winding insulation resistance has been raised to the highest achievable level the IR (Insulation Resistance) and PI should be re-measured using a megger or similar type instrument (remembering the winding temperature multiplying factor for 20 ºC correction).

The generator **must not** be put into service if the specified minimum values cannot be achieved. In this case, rewinding or refurbishment of the main stator winding will be necessary. Please refer to the factory for further information.

7.2. Fault finding

It is important to note that fault finding procedures vary between LV, MV and HV generators, in terms of knowledge requirements, competence, equipment and procedures. It is strongly recommended that the generator set fault finding be conducted under an Electrical Safety Permit system, to limit access to the plant and ensure health and safety procedures are adhered to at all times. Personal protective equipment must be used at all times.

Warning!

Under no circumstance, must low voltage test equipment be used to connect to MV and HV generator main stator windings when the generator is operating.

Danger!

To check the main terminal voltages, suitable equipment must be used by trained, competent personnel who are familiar with the generator construction and design.

Important! **Before commencing any fault finding procedures, shut the generating plant down, ensure full isolation, lock off and system earthing has been completed, then inspect all termination points an cables for broken, loose or disturbed connections.**

It is important to remember that the generator control system forms part of the genset control system. Where genset control systems are in place, identify any fault flags as indicated by the control system and determine if the fault flag is directly attributable to the generator, or is as a result of a failure elsewhere in the system, e.g. generator under frequency is reported – check prime move operation – possible causes: fuel flow, speed governing etc.

Note: Remember – the engine controls the kW and the generator controls the kVAr.

Important! **Before commencing any fault finding procedures examine all wiring for broken or loose connections.**

Where a generator fault is reported, the following table provides guidance on actions to identify the possible causes.

Fault	Action
No voltage build-up when starting set	Check the generator excitation circuit breaker state and / or the P2, P3 and P4 fused disconnect links (if fitted for remote mounted AVRs). Follow separate excitation or residual voltage tests.
Loss of voltage when set running	First stop and re-start set. If no voltage or voltage collapses after short time, check the generator excitation circuit breaker state and / or the P2, P3 and P4 fused disconnect links (if fitted for remote mounted AVRs), then follow the Separate Excitation Test Procedure.
Generator voltage high followed by collapse	Check sensing leads to AVR. Check isolating transformer secondary output. Check the generator excitation circuit breaker state and / or the P2, P3 and P4 fused disconnect links (if fitted for remote mounted AVRs). Refer to Separate Excitation Test Procedure.
Voltage unstable either on no-load or with load	Check speed. If correct, check “UFRO” setting. Refer to Load Testing - section 4 of the Installation manual.
Voltage low on load	Check speed. If correct, check “UFRO” setting. Refer to Load Testing - section 4 of the Installation manual.
Phase voltages unbalanced	Check stator winding and cables to main circuit breaker. Refer to unbalanced main terminal voltages.
Excessive voltage / speed dip on load switching	Check governor response – refer to generating set manual. Check “DIP” setting – refer to Load Testing – section 4 of the Installation manual.
Sluggish recovery on load switching	Check governor response – refer to generating set man. Check “DWELL” setting – refer to Load Testing – section 4 of the Installation manual.

7.3. Fault finding procedure

Important! **Before commencing physical inspection procedures, shut the generating plant down, ensure full isolation, lock off and system earthing has been completed.**

Inspect all termination points and cables for broken, loose or disturbed connections.

If the cause of the generator problem cannot be easily identified, a basic check of the generators major components should be undertaken.

These checks are often more easily and safely conducted with the generator running at rated speed and operating at only residual voltage levels.

A more in-depth testing procedure is to separately excite the generator. Comparisons of provided excitation levels against expected output terminal voltages will assist fault finding procedure.

The following individual sections progressively work through a fault finding procedure.

Danger!

Ensure that the generating set is in an operable condition, with any additional earths previously fitted during isolation and earthing are removed and any disturbed cables or terminations are remade. Ensure that the generator cannot inadvertently be paralleled to another source of AC power, by blocking the generator circuit breaker close command. Ensure remote operation of the generator circuit breaker cannot be achieved.

Residual voltage check – LV generators only

Identify and note the cable and termination markings for AVR leads F1 and F2. Disconnect the leads F1 and F2 from the AVR and isolate them to prevent contact with other termination points.

Danger!

Disconnecting the AVR leads F1 and F2 will prevent the generator main stator output from automatically building up beyond residual voltage levels. However, the Permanent Magnet Generator is independent of the main generator and so will still deliver full output voltage, dependent on the rotational speed of the generator, on AVR terminals P2, P3 and P4, up to a maximum of 300V AC, phase to phase.

Start the generating set, run at rated speed and measure voltages across AVR terminals 6-7-8 using suitable AC voltage test instrumentation. The terminals 6, 7 and 8 are a 3-phase AC supply derived from the generator main stator output terminals, through the primary and secondary winding arrangement of the isolation sensing transformer. These voltages should be balanced and in the order of values indicated in the machine parameter table (MPT).

Residual voltage levels are offered for guidance. Many factors affect residual voltage levels, the actual value not being too critical. However, it is important that the generated residual voltage levels are balanced across the three phases, and the ratio of main stator terminal voltage to the voltage on terminals 6-7-8 is in line with the above.

Residual balanced sensing terminal voltages

If all voltages are balanced within 1% at leads 6-7-8 it can be assumed that all exciter windings, main windings, main rotating diodes and the isolation sensing transformer are in good order.

A **separate excitation test** may now prove useful to confirm condition of main component assemblies.

Residual unbalanced sensing terminal voltages

If the voltages on terminal 6-7-8 are not balanced, the voltages across the main terminals should be measured using suitable instrumentation and personal protective equipment. These voltages should be balanced and in the order of values stated in the MPT.

Danger!

To check the main terminal voltages, suitable equipment must be used by trained, competent personnel who are familiar with the generator construction and design.

On MV and HV machines a matched set of high voltage potential dividers and associated instruments must be used. Terminal voltages can also be measured less accurately, using control / switchboard panel instrumentation.

If the main terminal voltages are unbalanced or low, a problem may exist with the generator main assemblies and the separate excitation test is necessary to identify the problem.

If the main terminal voltages are balanced and in line with the MPT, yet the voltages measured on 6-7-8 are unbalanced, the isolation sensing transformer is suspect. This should be tested for balanced winding resistances. If resistances are incorrect / unbalanced, a replacement transformer should be fitted. Refer to the factory for further advice.

Separate excitation test

The generator windings and rotating diode assembly can be checked using this procedure. With the generator stationary, remove the AVR access cover and AVR leads F1 and F2.

Open the excitation trip circuit breaker, if fitted or disconnect and remove K1 – K2 link from the AVR. This will stop the AVR from being activated during the separate excitation test.

Connect a 0 – 24V 1.0 amp DC supply to exciter stator winding leads (F1 – F2) which were previously disconnected from AVR.

Ensure lead F1 is connected to DC positive.
Ensure lead F2 is connected to DC negative.

It is often safer and more practical to work at reduced excitation / stator output voltages. This is often quite sufficient to prove the generator main assemblies.

However, a final test with generator separately excited to full rated stator output voltage is always recommended with the excitation amps and volts being noted and compared to the available test data.

With the DC supply to F1 – F2 set at zero volts, start the generating set and run at rated speed.

Slowly increase the DC supply voltage whilst monitoring the generator output terminal voltage.

Never allow the generator output terminal voltage to exceed the rated (nameplate) voltage. Do not exceed the rated excitation voltage. Do not exceed the rated excitation voltage or current.

Danger!

To check the main terminal voltages, suitable equipment must be used by trained, competent personnel who are familiar with the generator construction and design.

On MV and HV machines a matched set of high voltage potential dividers and associated instruments must be used.

Terminal voltages can also be measured less accurately, using control / switchboard panel instrumentation.

Measure the voltages of leads 6-7-8 which are still connected to AVR terminals 6-7-8 which is in fact the output voltage of the secondary windings of the isolation sensing transformer. These voltages should be balanced. If generator is separately excited to rated output voltage the voltages on 6-7-8 should be as indicated in the machine parameter table (MPT).

Separately excited balanced terminal voltages

If all voltages on leads 6-7-8 are balanced within 1% and in line with values stated in the machine parameter table (MPT) with the generator excited to full rated voltage, it can be assumed that all exciter windings, main windings, rotating diodes and the isolation sensing transformer are in good order.

Danger!

To check the main terminal voltages, suitable equipment must be used by trained, competent personnel who are familiar with the generator construction and design.
On MV and HV machines a matched set of high voltage potential dividers and associated instruments must be used.
Terminal voltages can also be measured less accurately, using control / switchboard panel instrumentation.

Separately excited unbalanced or low terminal voltages

If the voltages on 6-7-8 are not balanced or lower than in the MPT with generator separately excited to full rated voltage, a problem may exist with isolation sensing transformer windings. However, it should be established that stator output voltages are balanced and at expected voltage levels before suspecting a transformer problem.

Danger!

Before static winding resistances are measured, the generator set should be shut down, isolated and proved dead.
On MV and HV machines, a matched set of high voltage potential dividers and associated instruments must be used.
Terminal voltages can also be measured less accurately, using control / switchboard panel instrumentation.

The transformer winding resistances should be measured. These should be balanced and be in line with the values stated in the MPT.

If there is any doubt about condition of transformer a replacement should be fitted and the separate excitation test repeated to establish balanced – correct voltage levels on leads 6-7-8. Refer to factory for further advice.

Separately excited balanced main terminal voltages

If measured voltages are balanced and in accordance with values stated in the MPT under stated excitation levels, the generator main assemblies are working correctly.

Danger!

To check the main terminal voltages, suitable equipment must be used by trained, competent personnel who are familiar with the generator construction and design.
On MV and HV machines a matched set of high voltage potential dividers and associated instruments must be used.
Terminal voltages can also be measured less accurately, using control / switchboard panel instrumentation.

If measured voltages are balanced, but low, there is a fault in the main excitation windings or rotating diode assembly. Proceed as follows to check and identify faulty assembly.

Danger!

Ensure the generator set prime mover start circuits and all other sources of potential energy are isolated and locked off. The rotating rectifier forms an integral par of the generator rotor assembly and must be inhibited from rotation before protective safety covers are removed.

Rotating rectifier diodes

The rotating rectifier assembly is mounted on the generator shaft just inboard of the non drive end bearing. Access can be achieved by removal of the NDE cover followed by the air inlet screen.
Note: It will be necessary to unplug the PMG connector before removing the inlet screen – see Figure 7-2..

The diodes on the main rectifier assembly can be checked with a multimeter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions.

On an electronic digital meter a healthy diode will give a low reading in one direction and a high reading in the other. The rectifier assembly is split into two plates, the positive and negative and the main rotor is connected across these plates.

Each plate carries 3 diodes, the negative plate carrying negative biased diodes and the positive plate carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be over tightened. The recommended torque tightening is 4.06 – 4.74 Nm (36 – 42 lb in).

Surge suppressor

The surge suppressor consists of a matched pair of metal-oxide varistors connect across the two rotating rectifier plates. They are designed to prevent high transient reverse voltages, generated in the main rotor winding, from damaging the rotating diodes.

These devices are not polarised and will show virtually infinite readings in both directions if checked with an ordinary resistance meter. If defective it will be visible by inspection. Inspect both devices for signs of disintegration.

THESE UNITS MUST BE REPLACED AS MATCHED PAIRS.

The winding resistance values stated in the machine parameter table (MPT) are for typical generators designed to operate at the table indicated rated voltage. These resistance values should be used for guidance only, as an expected typical value, but also as a guide to the type of instrument that will be required to accurately measure the actual machine values. Each generator is despatched with and Information Documentation Package, which includes the ACTUAL winding resistance values measured for this specific generator.

Main excitation windings

If after establishing and correcting any fault on the rectifier assembly, the output is still low when separately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Tables). The exciter stator resistance is measured across leads F1 and F2. The exciter rotor is connected to six studs which also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings.

Resistance values should be within ± 10% of the values given in the machine parameter table (MPT).

Incorrect resistances indicate faulty windings and component replacement is necessary. Refer to dismantling / re-assembly procedures at the end of the section.

Separately excited unbalanced main terminal voltages

Danger!

On MV and HV machines a matched set of high voltage potential dividers and associated instrumentation must be used along with suitable rated and tested personal protective equipment.

Terminal voltages can also be measured less accurately, using control / switchboard panel instrumentation.

If the main terminal voltages are unbalanced, this indicates a fault on the main stator winding or main cables to the circuit breaker.
Note: Faults on the stator winding or cables may also cause noticeable load increase on the engine when excitation is applied.

Danger!

Before static winding resistances are measured, the generator set should be shut down, isolated and proved dead.

Disconnect the main cables and separate the three neutral winding leads or open the delta connection.

Measure each phase, resistance-values should be balanced and within ± 10% of the value given in the MPT.

Stator winding resistances may vary if the generator windings have been designed for a specific application. The factory can be consulted for confirmed winding resistances.

Measure insulation resistance of all phases as previously described under **Winding condition – section 1.1.**

Unbalanced or incorrect winding resistances and / or low insulation resistances to earth indicate rewinding of the stator will be necessary. Refer to removal and replacement of component assemblies at the end of the section.

Permanent magnet generator (PMG)

With the generating set stationary remove AVR access cover and AVR leads F1 and F2.

To establish that the PMG is working correctly, the following procedure should be carried out:

Start and run the generating set at rated speed

Measure the three phase output voltages of the PMG on AVR terminals P2, P3 and P4. these should be balanced and with the following range:

50 Hz generators 170 – 180 volts @ 100 Hz

60 Hz generators 200 – 216 volts @ 120 Hz

Important! Incorrect speed setting will give proportional error in voltage output.

Should the voltages be unbalanced, stop the generating set, remove the PMG sheet metal end cover from the non drive end bracket and disconnect the multi-pin plug in the PMG output leads. Check leads P2, P3 and P4 for continuity. Check the PMG stator winding resistances by measuring across P2 to P3 to P4. These should be balanced and within 10% of value given in the machine parameter table (MPT).

If resistances are unbalanced and / or incorrect, the PMG stator must be replaced. If the voltages are balanced by low and PMG rotor winding resistances are correct, the PMG rotor must be replaced.

AVR operation and adjustments

Please refer to the AVR specification, installation and adjustments manual for details.

This test is designed to prove an AVRs basic function.

With the generating set stationary, remove the AVR access cover and leads F1 and F2. Connect a 60W 240V household lamp (or two 120V lamps in series) to AVR terminal F1 and F2

Connect a 0 – 24V 1.0 amp DC supply to the leads F1, F2 having removed the leads from AVR terminals.

Ensure: F1 is connected to DC positive; F2 is connected to DC negative. Excitation circuit breaker is closed if fitted or K1 – K2 linked. Terminals 1 – 2 are linked or remote voltage trimmer is connected across these terminals. Leads 6-7-8 are connected to AVR and previous tests have established the

correct voltage is present. Leads P2, P3 and P4 are connected to AVR and previous tests have established the correct voltage is present.

Note: Do not run the machine without the terminal box lid fully bolted in place.

Warning!

During this test RATED VOLTAGE will exist at the generator main terminals. Ensure terminal box cover is fully bolted in place.

Connect a voltmeter to measure output terminal voltage L-L. Turn the AVR "volts" potentiometer fully clockwise. Set the DC supply to exciter field leads F1 – F2 to some 12V. Start the generating set and run at rated speed. Slowly adjust the DC supply until rated terminal voltage is being generated at control / switchboard panel instrumentation.

Caution! **Do not operate generator above rated terminal voltage.**

The lamp connected across AVR terminals F1 and F2 should glow for 8 – 10 seconds and then switch off.

If the lamp does not light, the AVR is faulty.

Replace AVR and repeat test.

Important! **After this test, turn the AVR "volts" potentiometer fully anti-clockwise.**

After rectification of any faults found remove all test connections, but leave voltmeter indicating L-L terminal voltage.

Replace leads F1 and F2 onto AVR.

Re-start the generating set and run at rated speed. Slowly adjust the AVR "volts" potentiometer clockwise to increase and set the generators output voltage to rated level at control switchboard panel instrumentation.

Refit all terminal box and access covers.

Danger!

Failure to re-fit all guards, access covers and terminal box covers can result in personal injury or death.

Removal and replacement of component assemblies

Metric threads are used throughout.

Danger!

When lifting single bearing generators, care is needed to ensure the generator frame is kept in the horizontal plane. The rotor is free to move in the frame and can slide out if not correctly lifted. Incorrect lifting can cause serious personal injury.

Important! **The following procedures assume that the generator has been removed from the generating set. On single bearing generators before removal from the engine, re-fit the transport plate under the fan hub. Failure to support the rotor before decoupling the generator from the engine will cause damage to the rotor field exciter.**

Removal of permanent magnet generator (PMG)

The PMG is located outboard of the generator's non drive end bearing.

With the generating set stationary, remove the non drive end polycarbonate cover.

Disconnect P2, P3 and P4 at the multi-way connector inside the air inlet cover.

Remove the fixing screws retaining the stator pack.

Tap the stator pack out of its spigot.

Important! **The highly magnetic rotor will attract the stator pack. Care must be taken to avoid a contact which may damage the stator pack winding.**

Remove the PMG rotor securing bolt, and firmly pull the complete rotor assembly from its location.

This highly magnetic rotor assembly must be handled carefully to keep clean and clear of metal dust or particles.

Place in a plastic bag as soon as is practicable.

Important! **The rotor assembly must not be dismantled.**

Re-assembly is a reversal of the above procedure having due regard for the notes below:

Ensure rotor magnet assembly is free of metal pieces or particles.

Care is needed to avoid winding damage during re-assembly of the stator pack, due to the strong magnetic attraction.

Re-assembly of PMG on to generator is reverse of above procedure. Care should be taken especially when offering stator over the highly magnetic rotor that windings are not damaged. All leads and loose items should be positioned and cable tied clear of any moving parts.

7.4. Bearings

The generator uses ball or roller bearings housed within a machine cartridge, which provides an effective sealed assembly. During generator manufacture the bearing-cartridge arrangement is

assembled with the correct amount of grease. Provision has been made for the bearings to be re-greased with a grease gun. It is important that the bearing assembly is never overfilled with grease. An information label has been fitted to the generator adjacent to each bearing with information regarding grease quantities and re-lubrication time periods.

Planned maintenance schedules should include for the bearing condition to be monitored using readily available bearing condition measuring equipment commonly used by maintenance personnel. If these results are recorded bearing life can be predicted and replacement planned.

Note: Even if the machine is in storage or has only run for a few hours in a given period, the bearings will need re-lubricating inline with the re-greasing schedule. The rotor must be periodically turned over if the machine is not in use to ensure that the bearings are provided with an adequate lubrication film. This should happen at least once a month. In the case of single bearing machines, if the machine is stored for more than 2 years, the bearing must be replaced – see Appendix 2 for details of bearing fitting.

Bearing failure

If a bearing has failed, for the factory to assist with an investigation in to the reason for failure, the information requested in Appendix 1 must be provided.

Bearing removal

Access to the bearing cartridge is only possible once the end bracket has been removed. End bracket removal is covered in the following sections.

The bearings are a press fit on the shaft end and can be removed with standard workshop tooling, i.e. two or three legged manual or hydraulic bearing pullers.

The non drive end bearing cartridge housing is machined to allow for an 'O' ring to be fitted which is designed to control the 'grip' on the bearing and allow axial float against a wave washer but not bearing out rotation. When access is available the condition of this 'O' ring should be examined and replaced if necessary.

Note: When refitting bearings the relevant 'Assembly specification' must be followed – refer to Appendix 2.

Bearing inspection

If a situation occurs which allows an opportunity to visually inspect a bearing with it still on the shaft the only guidance that the bearing is still serviceable may be the colour of the grease. New grease is a whitish-beige colour but some mild discoloration will occur with use. If the grease shows signs of gross discoloration and no visible lubricant then it would be prudent to change the bearing.

Removal of the bearing will involve bearing extraction tooling which exerts very high loads across the bearing as the outer race is pulled in an attempt to pull the bearing from the shaft. Once this operation has been carried out the bearing must not be re-used.

Bearing grease

New bearings **must** be filled with an appropriate lubricant as instructed below. The lubricant must be a grease type of the same grade as that used during the generators original manufacture.

The grease used is based on an Ester Oil Polyurea product, manufactured by **Kluber**, of a type called **Asonic GHY72**.

This grease can be recognised by its whitish-beige colour and its stiff consistency. It has been chosen for its superior lubricating properties under arduous conditions, and to provide the bearing with these lubricating characteristics this grease **must not** be mixed with any other type.

It is important that the correct quantity of grease is used for the initial fill for new bearings, and for periodic re-lubrication with a grease gun during planned maintenance.

Bearing Designation	Cage type	Grease fill quantity		Re-Lubrication	
		cm	Gram	Bearing speed (RPM)	Periods (Hrs)
6324 C3	Pressed steel	170	151	1500	1000-1500
				1800	1000-1500
6232 C3	Pressed steel	136	121	1500	1000-1500
				1800	1000-1500
6236 C3	Pressed steel	195	173	1500	1000-1500
				1800	1000-1500

Table 1-1

Customer re-lubrication for P80: **KLUBER ASONIC GHY72**

Table 1-1 shows quantities for customer periodic re-lubrication.

When re-lubricating the bearings it is important that the following points are adhered to:

Ensure that the grease, grease gun, grease gun nozzle and re-lubrication nipple are free from debris.

With the generator running, apply the specified quantity of grease via the grease nipple (see Table 1-2). The generator must be kept running for at least 10 minutes to allow excess grease to exhaust from the bearing assembly.

Exhausted grease can build up inside the PMG cover. Therefore, before applying lubricant, remove the rubber grommet in the cover to allow the excess grease to escape. Only refit the grommet once the bearing has stopped exhausting grease.

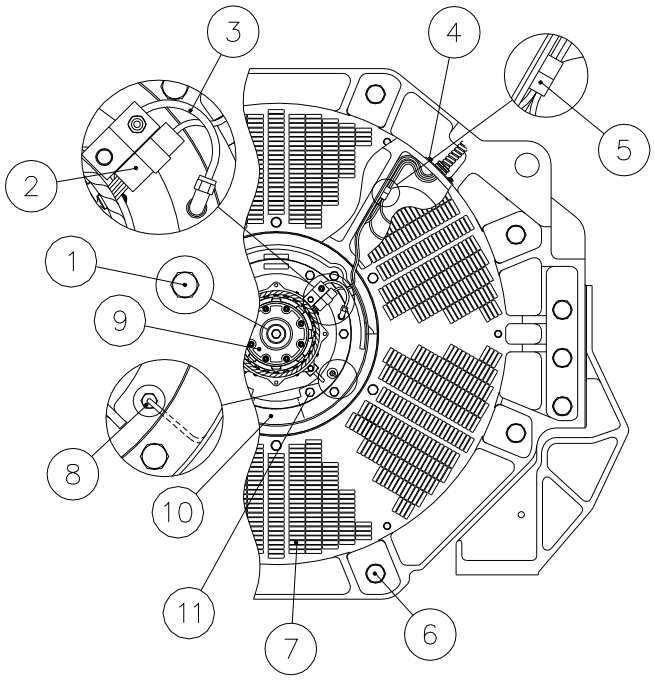
7.5. End bracket removal – refitting

Ensure the power supply to anti-condensation heaters is switched off and safely isolated.

Two bearing designs

Important! The end bracket removal MUST be undertaken in the following order:

1. The drive end (DE) bracket must not be removed unless the non drive end NDE bracket has first been removed.
2. Before disassembly commences, all tooling that comes into contact with greased parts must be thoroughly cleaned.

Figure 1-2 shows 

the NDE arrangement.

Figure 1-2

To remove the NDE bracket, firstly remove the air inlet cover (not shown), screen and control cabling fixing bracket (figure 7-2 items 8 and 5).

As the bearing cap incorporates limbs for supporting the PMG stator from the generator control wiring loom at the local plug and socket arrangement (figure 1-2 item 2).

Care will have to be taken to ensure the winding assembly is not damaged. This is achieved by disconnecting the PMG stator from the generator control wiring loom at the local plug and socket arrangement (Figure 1-2 item 2).

Next, remove the bold (Figure 7-2 item 1) that secures the PMG rotor to the shaft and the bolts holding the bearing cap in place (Figure 1-2 item 11). The whole assembly can not be withdrawn from the shaft.

To protect the bearing cap from contamination the PMG magnets from attracting debris, place the assembly in a sealed plastic bag and store in a safe place.

The weight of the rotor will be carried by the stator so the rotor core must be positioned with 2 poles in a vertical direction. This position can be identified by turning the rotor shaft until the keyway is in the vertical (12 o'clock) position. Also, to prevent damage to the DE bearing (2 bearing machines only) pack the air gap at the bottom with a rotor packer tool which must extend into the gap at lease 150 mm. This will minimise the tilt angle at the DE bearing.

Note: If the bearing(s) are seized and the shaft will not rotate, fit two packer tools that will support the bottom two poles.

Since the rear feet are attached to the NDE bracket, the machine must be supported using either Stamford tooling or a suitable support must be placed under the stator core with a bridge plate over both landing bars (avoid the landing bar overhangs).

Next, bolt the Stamford shaft extension tooling to the end of the rotor. To remove the bracket, support the weight of the rotor with a crane from the shaft extension tooling and then extract the 8 x M24 bolts (figure 1-2 item 6). The bracket is engaged tightly on the ends of the landing bars.

To remove the end plate, an Stamford jacking tool should be used to release it from the landing bars. When the bracket has been disengaged from the landing bars, gently lower the rotor onto the stator packer before pulling the bracket away from the rotor.

Note: The bracket will only have to move approximately 10 mm in the axial direction before it is disengaged.

The DE bracket consists of a master bracket to which the feet are fixed and a bearing carrier into which the bearing cartridge is housed (Figure 2-2 items 20 and 23). Normally only the bearing carrier will have to be removed.

Firstly, remove the grease pipe and disconnect the bearing RTDs (if fitted), then remove the air outlet screen, 6 x bearing cartridge bolts and 8 x M24 bolts (figure 1-3 item 3).

Note: The bearing carrier on W X and Y core machines is located with studs – therefore 8 x M24 nuts will have to be removed.

Next, support the weight of the rotor with a crane. The bearing carrier is located using ring dowels and will need to be jacked or tapped (using a mallet) away from the master bracket.

Once the bearing carrier is free of the bearing carrier, support the NDE of the shaft and remove the air gap packer.

Then gently lower the rotor onto the stator. The bearing carrier can now be drawn off the shaft.

Note: It is not necessary to remove the DE bearing cap.

Once the brackets have been removed the NDE bearing cap must be refitted and the grease fittings capped to prevent debris from entering the grease.

Single bearing designs

Before the alternator is disconnected from the engine, the rotor support bracket **must** be fitted (user during initial transportation). This is bolted to the alternator adapter ring and supports the shaft under the coupling hub. If this is not fitted, damage to the exciter field assembly will occur.

The removal of the NDE bracket must follow the above procedure except it will not be necessary to pack the air gap.

7.6. Rotor removal

With end brackets removed the rotor assembly is free to be taken out of the drive end of the stator assembly.

Due to the size and weight of the rotor, it is recommended that only Stamford tooling be used to remove the rotor.

Equipment**:**

A steel stub shaft which is located off the NDE of the shaft / bearing cartridge.

A thick walled steel tube that will support the rotor and reach through the complete length of the machine

A 'Vee' shaped roller assembly, mounted within a cradle securely fitted to the top of a jack.

A hoist / crane and sling cable of taking the full weight of the rotor.

Note: Rotor loadings are available from the factory.

Procedure:

1. The stub shaft is secured to the bearing cartridge / shaft at the NDE of the rotor shaft.
2. The jack complete with "Vee" roller is positioned as close as possible to stator frame assembly and the roller is located under and against the tube.
3. A rope sling is used to lift and manoeuvre the drive end of the rotor.
4. The NDE of the rotor is lifted by the jack "Vee" roller assembly.
5. The rotor is carefully moved through the stator frame assembly until at least the main rotor core and windings are clear of the stator bore and windings.
6. At this point the drive end of the rotor assembly must be supported on wooden blocks in a manner such that there is no risk of the rotor rolling sideways. With the rotor supported on wooden blocks, the rope sling can be moved to a central position on the main rotor core, where it should be tightly bound to enable the rotor to be lifted and guided clear of the stator frame assembly.

Important! The rope sling may not be at the centre of gravity of the rotor and guidance at the ends of the rotor is essential.

As the rotor is fully withdrawn from the stator core, THE FULL WEIGHT OF THE ROTOR MUST BE SUPPORTED BY THE CRANE. If the rotor core is allowed to drop more than a few millimetres at this point, it will make contact with the stator windings and may damage them.

Re-assembly is a reversal of the above procedure. However, to avoid damage to the bearing, the shaft extension tooling must be securely bolted to the shaft end using 3 x M16 cap screws and the NDE bracket axial location fixture must be positioned so that the NDE bracket is locked axially to the extension tooling.

The above describes the ideal procedure where all the required equipment and tools are available.

In service this is not often the case.

It is hoped that sufficient guidance has been given to impress the need for very careful handling with correctly sized lifting equipment. Individual lifting of both ends of rotor is necessary by equipment that allows axial movement once rotor weight is being supported.

Note: When re-tightening fasteners the following torque settings must be used:

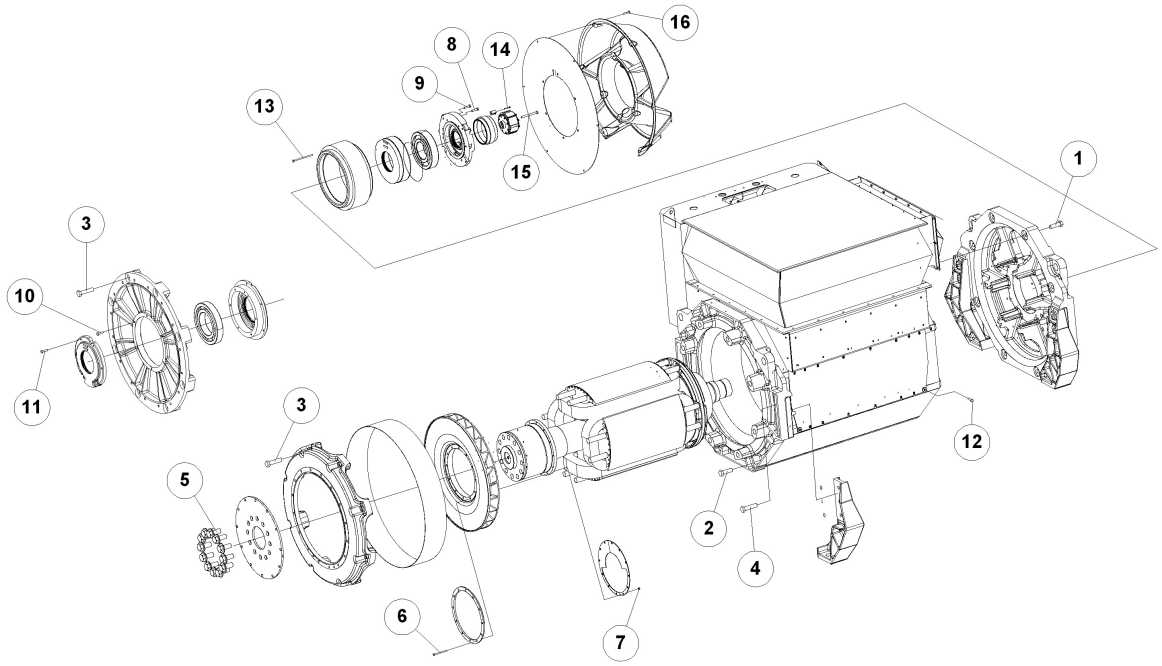


Figure 1-3

Fastener Tightening Torque Values

Reference (Figure 1-3))	Description	Torque setting (Nm)
1	NDE bracket (to landing bar) – M24	660
2	DE bracket (to landing bar) – M24	660
3	Bearing carrier / adapter ring – M24	660
4	Feet fixing – M24	660
5	Coupling disc to hub – M30	1350
6	Fan fixing – M10	31.5
7	Balance weight - M10	45
8	NDE bearing cartridge – M10	45
9	NDE bearing cap – M10	45
10	DE bearing cartridge – M10	45
11	DE bearing cap – M10	45
12	Side panels / base plate – M12	78
13	Exciter stator stud – M8	22
14	PMG Stator – M6	9.4
15	PMG Rotor – M10	45
16	Air inlet cover – M8	8

Table 1-2

Single bearing coupling plates

Before assembly of a single bearing rotor into stator housing, check that the drive discs are not damaged, cracked or showing any other signs of fatigue, and that the holes in the discs are not elongated.

Damaged components must be replaced.

The number of coupling discs required and the tightening torque for discs to coupling hub are detailed in Table 1-3.

Number of discs	Thickness of each disc (mm)	Total thickness of combined plates (mm)	Bolt size	Torque setting for the disc to coupling hub fixing bolts	
				kgm	Nm
10	1.2	12	M30	138	1350

Table 1-3

Refer to engine manual for torque setting of disc to flywheel fixing bolts.

Two bearing generators

The previously described method of preparation and then removal of end brackets should be referred to and followed.

Two bearing generators have certain deviations from single bearing generators, because the two bearing generator is designed to positively locate the rotor in a fixed axial position.

Deviation:

1. No circlip is fitted on shaft outboard of NDE bearing.
2. A “wave washer” is fitted within the non drive end bearing cartridge, outboard of bearing.

Removal of rotor from stator is achieved by the method previously described.

Stator assembly

The stator pack is supported and concentrically located within a construction consisting of eight stator support bars (landing bars) which have been welded equi-spaced around the outside of the stator pack, the ends of which have been machined to accurately locate into substantial end brackets which form both a concentric location for end brackets and the generators feet. These end brackets are bolted to the stator support bars.

Should it be necessary to remove the end brackets, care should be taken during handling and supporting the stator pack, such that no undue strain is applied to a support bar, which could result in a support bar being bent and therefore misaligned, resulting in loss of alignment.

LV804 Parameters

Frame Size	L-L AC Volts	Freq. Hz	Typical Residual AC Voltages		Normal AC Voltage on Terminals 6,7,8	Transformer Primary Winding Ohms 20 C	Transformer Secondary Winding Ohms 20 C	Exciter Stator Winding Ohms 20 C	Exciter Rotor Winding L-L Ohms 20 C	Main Rotor Winding Ohms 20 C	Main Stator L-N Ohms 20 C	PMG Stator Winding Ohms 20 C
			Term'ls 6,7,8	Main L-L Term'ls								
LV804R	400	50	35	60	190-250	Refer to	Refer to	17.5	0.075	1.32	0.00069	2.7
	690	50	35	100	190-250	Factory	Factory	17.5	0.075	1.32	0.00158	2.7
	480	60	35	70	190-250	"	"	17.5	0.075	1.32	0.00069	2.7
	600	60	35	90	190-250	"	"	17.5	0.075	1.32	0.00097	2.7
LV804S	400	50	35	60	190-250	"	"	17.5	0.075	1.40	0.00054	2.7
	690	50	35	100	190-250	"	"	17.5	0.075	1.40	0.00145	2.7
	480	60	35	70	190-250	"	"	17.5	0.075	1.40	0.00054	2.7
	600	60	35	90	190-250	"	"	17.5	0.075	1.40	0.00078	2.7
LV804T	400	50	35	60	190-250	"	"	17.5	0.075	1.50	0.00044	2.7
	690	50	35	100	190-250	"	"	17.5	0.075	1.50	0.00115	2.7
	480	60	35	70	190-250	"	"	17.5	0.075	1.50	0.00044	2.7
	600	60	35	90	190-250	"	"	17.5	0.075	1.50	0.00075	2.7
LV804W	400	50	35	60	190-250	"	"	17	0.090	1.47	0.00033	2.7
	690	50	35	100	190-250	"	"	17	0.090	1.47	0.00090	2.7
	480	60	35	70	190-250	"	"	17	0.090	1.47	0.00033	2.7
	600	60	35	90	190-250	"	"	17	0.090	1.47	0.00048	2.7
LV804X	400	50	35	60	190-250	"	"	17	0.090	1.63	0.00027	2.7
	480	60	35	70	190-250	"	"	17	0.090	1.63	0.00027	2.7
	600	60	35	90	190-250	"	"	17	0.090	1.63	0.00037	2.7
LV804Y	690	50	35	100	190-250	"	"	17	0.090	1.69	0.00066	2.7

MV804 Parameters

Frame Size	L-L AC Volts kV	Freq. Hz	Typical Residual AC Voltages		Normal AC Voltage on Terminals 6,7,8	Transformer Primary Winding Ohms 20 C	Transformer Secondary Winding Ohms 20 C	Exciter Stator Winding Ohms 20 C	Exciter Rotor Winding L-L Ohms 20 C	Main Rotor Winding Ohms 20 C	Main Stator L-N Ohms 20 C	PMG Stator Winding Ohms 20 C
			Term'ls 6,7,8	Main L-L Term'ls								
MV804R	3.3	50	35	500	190-250	Refer to	Refer to	17.5	0.075	1.32	0.0338	2.7
						Factory	Factory					
	4.16	60	35	650	190-250			17.5	0.075	1.32	0.0338	2.7
MV804S	3.3	50	35	500	190-250	"	"	17.5	0.075	1.40	0.0334	2.7
	4.16	60	35	650	190-250	"	"	17.5	0.075	1.40	0.0334	2.7
MV804T	3.3	50	35	500	190-250	"	"	17.5	0.075	1.50	0.0281	2.7
	4.16	60	35	650	190-250	"	"	17.5	0.075	1.50	0.0281	2.7
MV804W	3.3	50	35	500	190-250	"	"	17	0.090	1.47	0.0192	2.7
	4.16	60	35	650	190-250			17	0.090	1.47	0.0192	2.7
MV804X	3.3	50	35	500	190-250	"	"	17	0.090	1.63	0.0153	2.7
	4.16	60	35	650	190-250	"	"	17	0.090	1.63	0.0153	2.7

HV804 Parameters

Frame Size	L-L AC Volts kV	Freq. Hz	Typical Residual AC Voltages		Normal AC Voltage on Terminals 6,7,8	Transformer Primary Winding Ohms 20 C	Transformer Secondary Winding Ohms 20 C	Exciter Stator Winding Ohms 20 C	Exciter Rotor Winding L-L Ohms 20 C	Main Rotor Winding Ohms 20 C	Main Stator L-N Ohms 20 C	PMG Stator Winding Ohms 20 C
			Term'ls 6,7,8	Main L-L Term'ls								
HV804R	6.0	50	35	900	190-250	Refer to	Refer to	17.5	0.075	1.32	0.1489	2.7
	6.6	50	35	1000	190-250	Factory	Factory	17.5	0.075	1.32	0.1636	2.7
	10	50	35	1500	190-250	"	"	17.5	0.075	1.32	0.4716	2.7
	11	50	35	1650	190-250	"	"	17.5	0.075	1.32	0.6007	2.7
	7.2	60	35	1100	190-250	"	"	17.5	0.075	1.32	0.1489	2.7
	13.8	60	35	2100	190-250	"	"	17.5	0.075	1.32	0.6736	2.7
HV804S	6.0	50	35	900	190-250	"	"	17.5	0.075	1.40	0.1243	2.7
	6.6	50	35	1000	190-250	"	"	17.5	0.075	1.40	0.1549	2.7
	10	50	35	1500	190-250	"	"	17.5	0.075	1.40	0.3833	2.7
	11	50	35	1650	190-250	"	"	17.5	0.075	1.40	0.4903	2.7
	7.2	60	35	1100	190-250	"	"	17.5	0.075	1.40	0.1243	2.7
	13.8	60	35	2100	190-250	"	"	17.5	0.075	1.40	0.5554	2.7
HV804T	6.0	50	35	900	190-250	"	"	17.5	0.075	1.50	0.1068	2.7
	6.6	50	35	1000	190-250	"	"	17.5	0.075	1.50	0.1305	2.7
	10	50	35	1500	190-250	"	"	17.5	0.075	1.50	0.2981	2.7
	11	50	35	1650	190-250	"	"	17.5	0.075	1.50	0.4022	2.7
	7.2	60	35	1100	190-250	"	"	17.5	0.075	1.50	0.1068	2.7
	13.8	60	35	2100	190-250	"	"	17.5	0.075	1.50	0.4484	2.7
HV804W	6.0	50	35	900	190-250	"	"	17	0.090	1.47	0.0668	2.7
	6.6	50	35	1000	190-250	"	"	17	0.090	1.47	0.0888	2.7
	10	50	35	1500	190-250	"	"	17	0.090	1.47	0.2368	2.7
	11	50	35	1650	190-250	"	"	17	0.090	1.47	0.3294	2.7
	7.2	60	35	1100	190-250	"	"	17	0.090	1.47	0.0668	2.7
	13.8	60	35	2100	190-250	"	"	17	0.090	1.47	0.3724	2.7
HV804X	6.0	50	35	900	190-250	"	"	17	0.090	1.63	0.0526	2.7
	6.6	50	35	1000	190-250	"	"	17	0.090	1.63	0.0717	2.7
	10	50	35	1500	190-250	"	"	17	0.090	1.63	0.1943	2.7
	11	50	35	1650	190-250	"	"	17	0.090	1.63	0.2540	2.7
	7.2	60	35	1100	190-250	"	"	17	0.090	1.63	0.0526	2.7
	13.8	60	35	2100	190-250	"	"	17	0.090	1.63	0.2868	2.7

3. Spares and after sales service

7.7. Recommended spares

Service parts are conveniently packaged for easy identification.

We recommend the following for service and maintenance. In critical applications a set of these service spares should be held with the generator.

1. Diode set (6 diodes with surge suppressors).
   FRAME 8 RSK6001

MA330 AVR E000 – 13300 or third part AVR manufacturer

Bearings

	DE	NDE
R.S.T. CORES	051-01059	051-01066
W.X.Y CORES	051-01060	051-01066

When ordering parts the machine serial number and type should be quoted, together with the part description. The serial number is stamped on the nameplate and on the drive end of the shaft.

Orders and enquiries for parts should be addressed to the factory, or any of our subsidiary companies listed on the back cover.

7.8. After sales service

A full technical advice and on-site service facility is available from our Service department in Ingolstadt or through our subsidiary companies. A repair facility is also available at our Ingolstadt works.

7.9. Kluber Asonic grease

This special high grade EsterOil / Polyurea grease is available worldwide.

For your nearest stockist, we suggest you contract the manufacturers:

Kluber Lubrication München:-
Tel: +49 89 78760
Fax: +49 89 7876333

PARTS LIST

TYPICAL P80 SINGLE BEARING GENERATOR

Plate Ref.	Description	Plate Ref	Description
1	NDE Bracket	25	Frame Cover - Upper Half
2	DE Bracket	26	Saddle Assembly
3	DE Screen	27	Side Cover
4	Wound Main Stator	28	Frame Cover - Lower Half
5	Wound Main Rotor	29	Main Rectifier Assembly
6	Wound Exciter Stator	30	Diode-Reverse Polarity
7	Wound Exciter Rotor	31	Diode-Forward Polarity
8	Fan Clamp Ring	32	Varistor
9	Fan		
10	Shaft		
11	PMG Stator Assembly		
12	PMG Rotor Assembly		
13	NDE Cover		
14	Air Inlet Screen		
15	PMG Rotor Bolt		
16	PMG Stator Clamp		
17	NDE Bearing		
18	NDE Cap/PMG Stator Mounting		
19	NDE Bearing Cartridge		
20	Coupling Disc		
21	Coupling Bolt Washer		
22	Coupling Disc Bolt		
23	DE Adaptor		
24	Foot		

NDE	Non Drive End
DE	Drive End
PMG	Permanent Magnet Generator

Table 2-1

TYPICAL P80 SINGLE BEARING GENERATOR

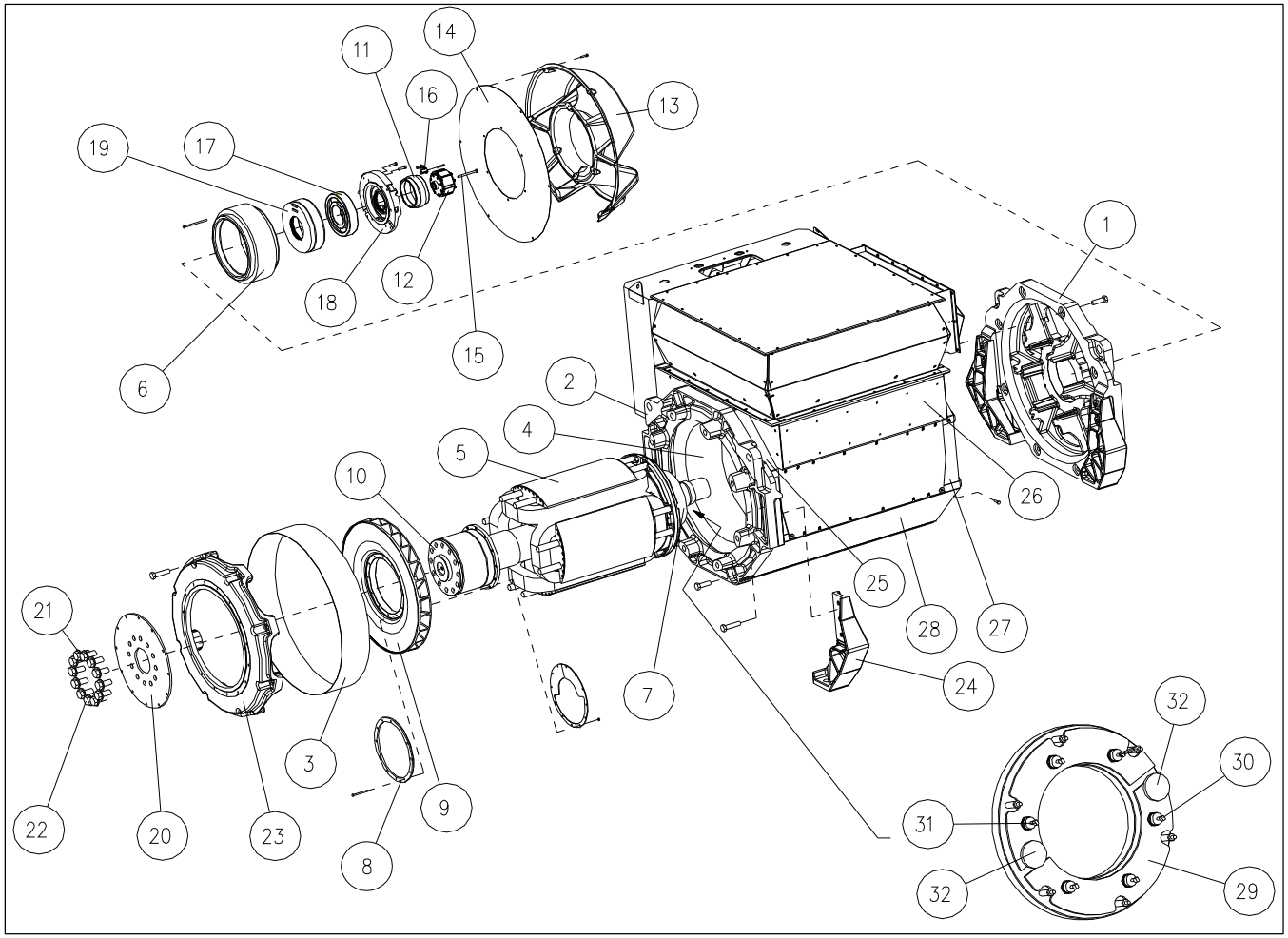


Figure 2-1

PARTS LIST

TYPICAL LV8 TWO BEARING GENERATOR

Plate Ref.	Description	Plate Ref	Description
1	NDE Bracket	25	Frame Cover - Upper Half
2	DE Bracket	26	Saddle Assembly
3	DE Screen	27	Side Cover
4	Wound Main Stator	28	Frame Cover - Lower Half
5	Wound Main Rotor	29	Main Rectifier Assembly
6	Wound Exciter Stator	30	Diode- Reverse Polarity
7	Wound Exciter Rotor	31	Diode- Forward Polarity
8	Fan Clamp Ring	32	Varistor
9	Fan		
10	Shaft		
11	PMG Stator Assembly		
12	PMG Rotor Assembly		
13	NDE Cover		
14	Air Inlet Screen		
15	PMG Rotor Bolt		
16	PMG Stator Clamp		
17	NDE Bearing		
18	NDE Cap/PMG Stator Mounting		
19	NDE Bearing Cartridge		
20	DE Bearing Cartridge		
21	DE Bearing		
22	DE Bearing Cap		
23	DE Bearing Carrier		
24	Foot		

NDE Non Drive End
DE Drive End
PMG Permanent Magnet Generator

Table 2-2

TYPICAL P80 TWO BEARING GENERATOR

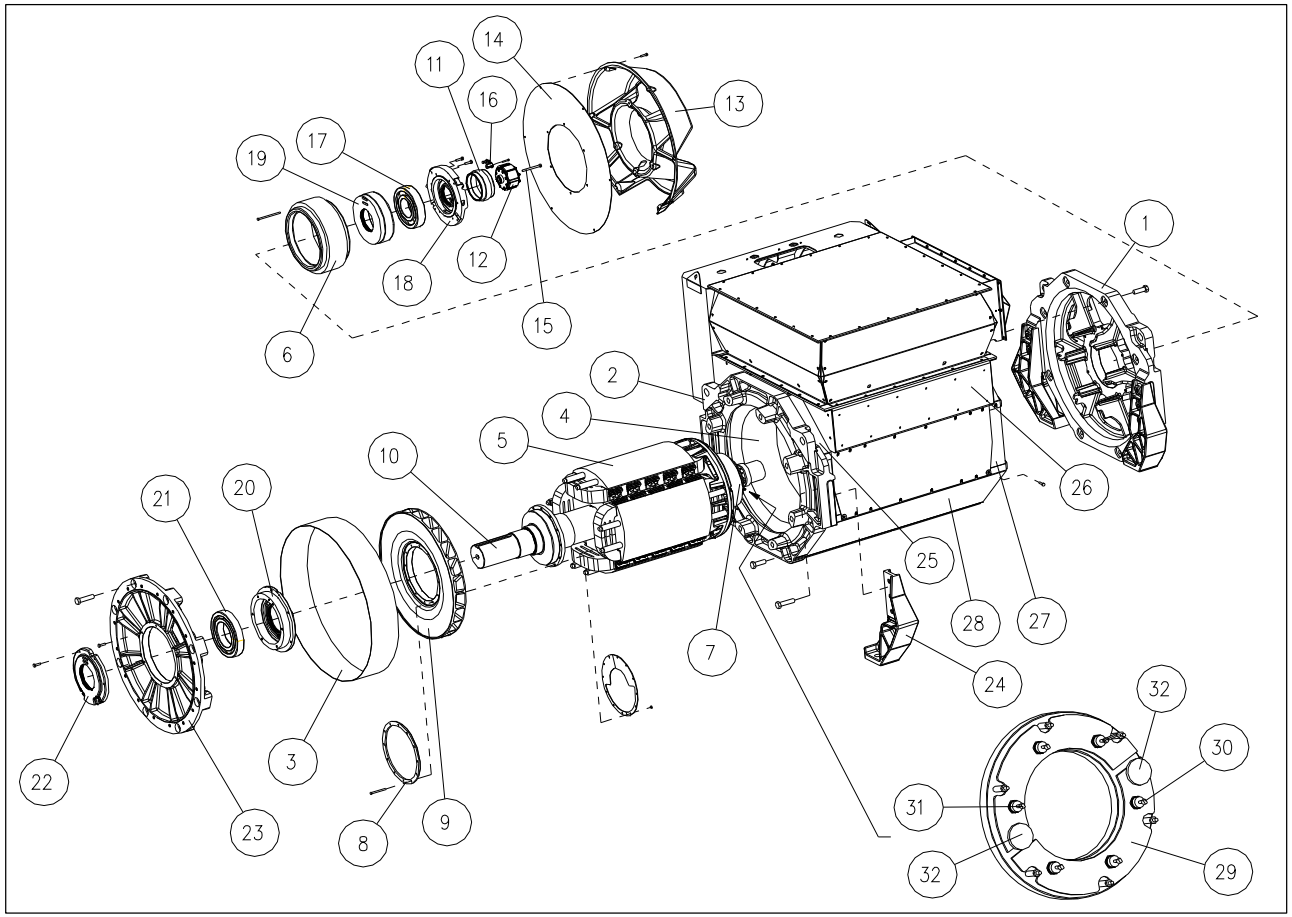


Figure 2-2

TYPICAL P80 GENERATOR LV TERMINAL BOX

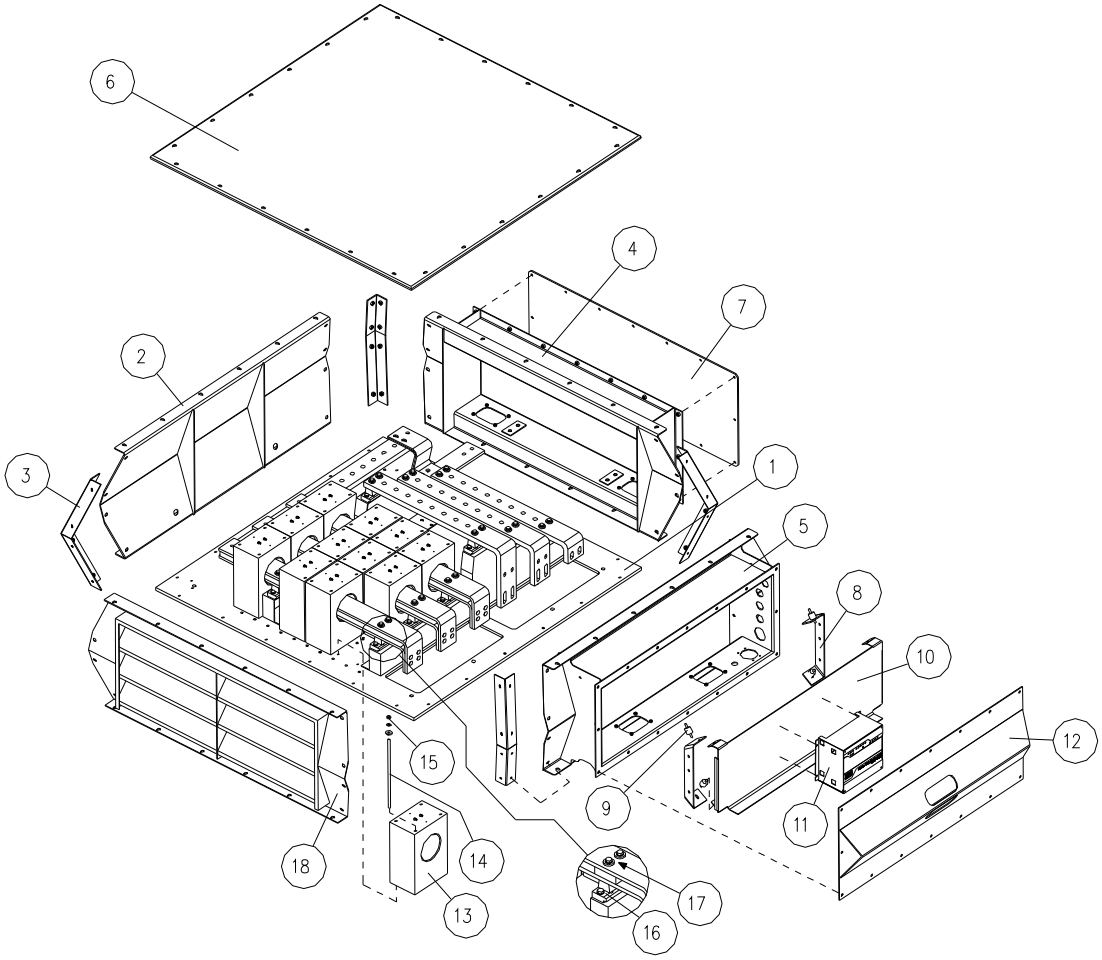


Figure 2-3

PARTS LIST

TYPICAL LV80 TERMINAL BOX

Plate Ref.	Description
1	Terminal Box Base Plate
2	Terminal Box End Panel - DE
3	Corner Piece
4	Connection Box
5	Auxiliary Terminal Box
6	Terminal Box Lid
7	Gland Plate
8	AVM mounting Bracket
9	AVM
10	Auxiliary Terminal Box Panel
11	AVR (typical arrangement)
12	Auxiliary Terminal Box Cover
13	CT
14	Stud – CT
15	Nut – CT
16	Isolator Clamping Screw
17	Busbar Fix Screw
18	Air Inlet Panel

Torque Settings		
Item No.	Description	Torque (Nm)
15	CT fixing – M8	22
16	Isolator Clamp – M8	20
17	Busbar Fixing – M8	30
-	Stator Lead Lug – M12	80
-	Busbar Star Point – M10	45

PMG	Permanent Magnet Generator
AVR	Automatic Voltage Regulator
PFC	Power Factor Controller
AVM	Anti-vibration Mount

Table 2-3

TYPICAL P80 GENERATOR MV / HV TERMINAL BOX

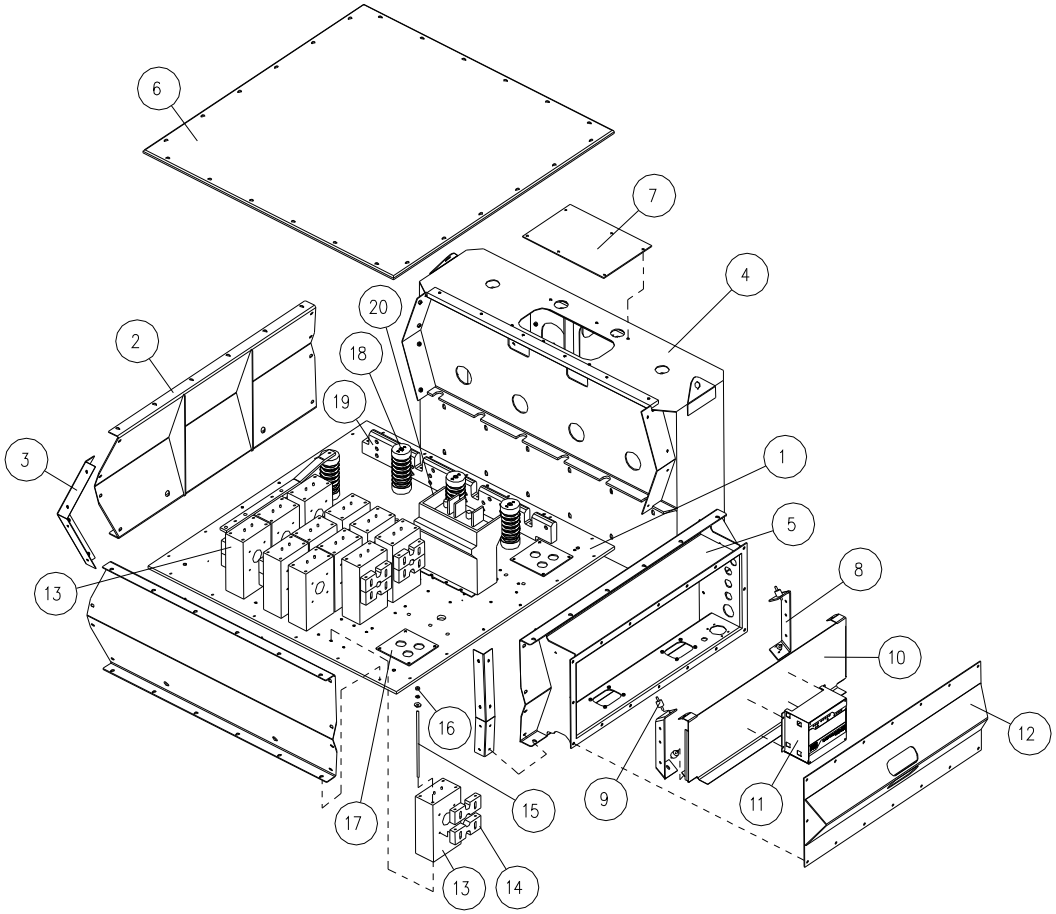


Figure 2-4

PARTS LIST

TYPICAL MV / HV80 TERMINAL BOX

Plate Ref.	Description
1	Terminal Box Base Plate
2	Terminal Box End Panel - DE
3	Corner Piece
4	Connection Box
5	Auxiliary Terminal Box
6	Terminal Box Lid
7	Gland Plate
8	AVM mounting Bracket
9	AVM
10	Auxiliary Terminal Box Panel
11	AVR
12	Auxiliary Terminal Box Cover
13	CT
14	Cable Clamp
15	Stud - CT
16	Nut - CT
17	Gland Plate
18	Post Insulator
19	Cable Support
20	Isolating Transformer

PMG	Permanent Magnet Generator
AVR	Automatic Voltage Regulator
PFC	Power Factor Controller
AVM	Anti-vibration Mount

Torque Settings		
Item	Description	Torque (Nm)
16	CT fixing – M8	22
18	Nut – M12 Post insulator	80

Table 2-4

LV8 ROTATING RECTIFIER ASSEMBLY

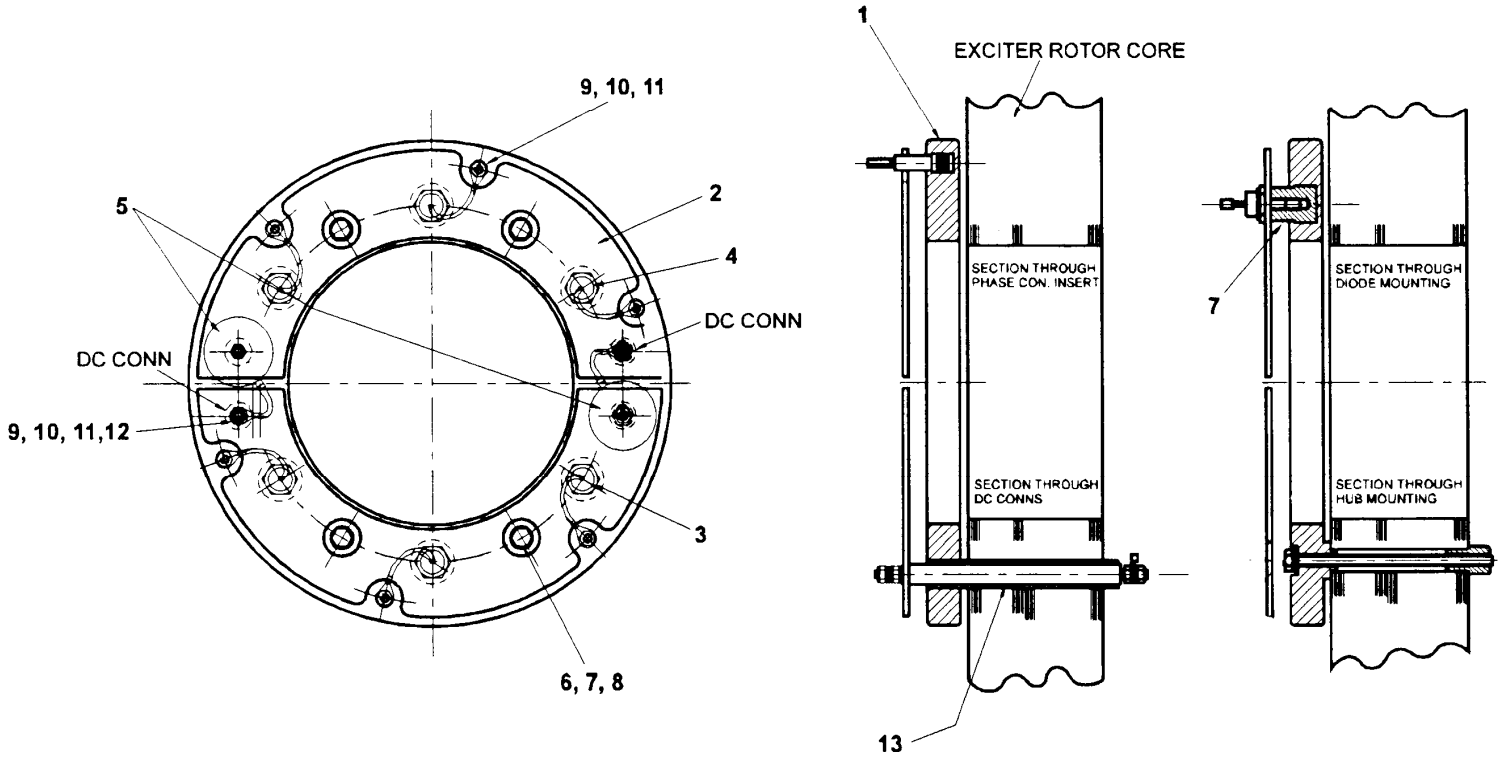


Figure 2-5

PARTS LIST
TYPICAL MV / HV80 TERMINAL BOX

Plate Ref	Description	Qty
1	Rectifier Hub	1
2	Rectifier Fin	2
3	Diode Lead Assembly (Forward)	3
4	Diode Lead Assembly (Reverse)	2
5	Varistor Assembly	2
6	Hexagonal Head Screw	4
7	S.C. Lock washer	4
8	Plain Washer	4
9	Hex Nut	17
10	S.C. Lock washer	15
11	Plain Washer	21
12	CH.HD. Screw	1
13	Through Stud Assembly	1

1. A rectifier assembly **must** comprise diodes from one manufacturer only.
2. 4 Bolts (Plate ref 6) holding the moulding to the exciter core should be given an application of Loctite 241.
3. When fitting replacement diodes the undersides should if possible be smeared with Midland Silicone Heat Sink compound Type MS2623 or similar. **IMPORTANT:** This compound **MUST NOT** be applied to the diode stud threads.
4. Diode tightening torque: 4-4.8N-m (36 — 42 lb-in).

Table 2-5

Appendix 1

In the event of a bearing failure for the cause to be correctly determined, the following information must be provided (fill in the boxes).

Ref	Information required for bearing failure assessment:	Yes / No	Comment / Values
	Items that may / can be determined off site:		
1	What is the machine serial number?		
2	What is the generator application e.g. marine, industrial, dock-side crane, etc.?		
3	Single bearing or two bearing?		
4	How may hours has the machine run to date?		
5	What type of engine / generator coupling is fitted e.g. steel gear tooth coupling, rubber insert coupling, rubber gear tooth, drive discs, etc.? Manufacturer and model of coupling:		
6	What was the mode of transport for the machine being shipped from the factory to site? Rail, truck, conditions of roads, etc.		
7	What was the minimum temperature experienced by the machine during transportation? (Winter in extreme locations – brittle fracture)		
8	How was the set aligned? Please provide the alignment data at commissioning / manufacture		
9	Is the skid construction one or two piece, machined or fabricated only?		
10	Type of NDE bearing fitted – designation (stamped on the front of the bearing)?		
11	Type of DE bearing fitted – designation (stamped on the front of the bearing)? Not easily viewed on-site.		
12	What is the mass of the coupling?		
13	Is the machine installed in an earth quake zone?		
14	What was the coupling stiffness / rubber hardness at the time of installation? (Shore hardness).		

15	What is the coupling stiffness / rubber hardness at the time of failure? (Shore hardness).		

16	For sets including gear box / gas turbine / steam turbine was a hot / cold alignment procedure followed? If so, what?		
17	Remove bolts at the FW housing interface and measure and record the gap at the top and bottom and side to side at the interface. This will allow the machine to move within the clearance of the spigot if there is misalignment. For this disengagement of spigot is necessary. (Shimming may correct all of these).		
18	On two bearing machines, what is the axial position of the coupling (if fitted)? Check potential for thrusting on DE bearing.		
19	What is the maximum operating speed of the generator (speed history – as a variable speed if not synchronised)? Was there any history of over speed above 1800 rpm? If so, define.		
20	Is there any evidence of bearing fretting (dark brown / orange discharge into the low grease area)? Most typical location is NDE. Can be inspected without major strip down of machine.		
21	Are the bearings seated against their abutments (shoulder) – clock the inner ring relative to the housing (10 mm limit)? Evidence is high axial vibration. Can only be accomplished with a freely rotating shaft on two bearing machines. On single bearing machines without factory test adapter on DE it is impossible to do in field on NDE.		
22	What is the DE bearing RTD alarm setting?		
23	What is the DE bearing RTD trip setting?		
24	What is the NDE bearing RTD alarm setting?		
25	What is the NDE bearing RTD trip setting?		
26	Is there an SPM (Spike energy / bearing signature) bearing trend data available?		
27	Is the alternator ever stationary when other local equipment is operational? Indicator for potential false Brinelling caused by vibrations from adjacent equipment.		

28	Condition of the (NDE) wave washer? Can be obtained without major machine disassembly.		
29	Condition of the bearing cartridge NDE 'O' ring. Need to pull bearing to inspect for fretting corrosion.		

30	Has the correct specification grease been used for re-lubrication? (Check colour and consistency. Have they got any on site?		
31	Is there any evidence of contamination in the most recently applied lubricant (colour, dark particles, etc.)?		
32	If the machine was idle for a period greater than two months, was machine re-greased before start-up or the shaft periodically rotated?		
33	If the machine has not been running continuously, has the re-greasing regime been followed? (See maintenance manual i.e. all greases have a limited shelf life).		
34	If the machine has been running continuously, has the re-greasing regime been followed?		
35	Are grease samples available from within the bearing (grease from around the rolling elements)? Please provide samples in a sealed clean container (up to 5 c.c.)		
36	Ensure there is a blanking plug fitted in the bearing cartridge cross drilling.		
37	If fitted, is the auto-lubricator empty or is it air-locked?		
38	Is there any water in the bearing e.g. due to high pressure water or steam cleaning or local flooding?		
39	What is / was the maximum ambient temperature in the plant room with blocked inlet filters due to dust, fibres, snow / ice? The temperature may be raised.		
40	If fitted, are the generator air inlet filters clean and is a differential pressure switch fitted and operational (alarm at ¾ inch and trip 1 inch – approx. values expected)?		
41	What are the DE vibration levels at the ISO		

	measuring points (limit = 18 mm/s rms)? Horizontal and vertical at bearing location.		
42	What are the NDE vibration levels at the ISO measuring points (limit = 18 mm/s rms)? Horizontal and vertical at bearing location.		
43	What is the DE axial vibration level at the ISO measuring point?		
44	What is the NDE axial vibration level at the ISO measuring point?		
45	What are the acceleration readings at the bearing locations in 3 planes – axial, vertical and horizontal? Get as close to bearing location as possible. On NDE remove PMG / air inlet cover for best readings.		
46	If fitted, what are the bearing vibration alarm trip settings set at?		
47	Has the 'Shock Watch' device fitted inside the terminal box been activated or tampered with?		
48	Was there any possibility genset was started with bearings / shaft at very low temperatures? (<- 15 ºC)		
49	What is the floor flatness under the genset? For machines with AVM between engine and generator and skid, 3 mm flatness under genset. With height adjustable AVMs beneath skid, 10 mm flatness under genset (measure with laser level).		
50	Is the set on AVMs or is the set "hard" mounted?		
51	Where are the AVMs located (under the machine or under the bed rail or both – describe)?		
52	Are the AVMs adjustable to compensate for floor / container unevenness?		
53	Check coding / ID on AVMs to see if correctly positioned.		
54	Is there any evidence of post commissioning foundation movement, heaving or cracking e.g. permafrost or clay movement?		
55	Are there any expansion joints in the concrete floor under the genset?		

56	For marine installations, please provide details of the ships mounting structure (stiffness).		
57	On spark ignition engines is the spark plug earthing path independent of the alternator?		
58	Is there any evidence of bending on skid members for indication of excessive force during transportation or installation? (Especially cross members or beams which have most bending moment).		

Note: This is not an exhaustive list of factors so please add other relevant information.

SAFETY NOTE: These tests should only be carried out by qualified and approved personnel acting in accordance with site and or local regulations regarding safety (mechanical and electrical).

Appendix 2

Bearing assembly specification

Pre-assembly preparation:

Environment: Assembly of all bearings must occur in a clean area free from static / airborne dirt. All tooling should be stored and used in the 'clean area'.

Equipment:

- White coloured anti-static mounting surface.
- Calibrated grease dispenser.
- Component washing equipment or use pre-washed parts.
- Suitable cleaning solvent if parts are not pre-washed.
- Bearing induction heater, complete with protective sleeve on bar.
- Thin protective gloves.
- Lint free cleaning cloth.
- Bearing insertion tooling – pressing.

Pre-assembly cleaning:

Note: Gloves must be worn at all times when handling the bearings, grease and solvent.

1. Wipe clean the anti-static assembly surface, using solvent on lint free cloth.
2. If not pre-washed, wash bearing cartridge, wavy washer and the bearing cap. Visually inspect all components after washing for contamination.
3. If applicable, wipe of excess washing fluid with lint free cloth and place all components on the clean anti-static assembly surface. Do not use an air line to blow off excess fluid.
4. Thoroughly clean the external surface of the grease gun nozzle using lint free cloth.

Bearing preparation:

1. Remove the bearing from its packaging.
2. Wipe off the preservative oil from the surface of the inner and outer rings – using lint free cloth only.
3. Place the bearing on the clean anti-static assembly surface, with the bearing designation marking face down.

Bearing assembly:

Cartridge:

1. Apply the specified cartridge grease fill quantity (**see table A-4**) to the back face of the bearing housing.
2. Apply a small amount of grease to the grooved sealing surface in the cartridge.
3. Apply anti-fretting lubricant (**MP 14002 – Kluber Altemp Q NB 50**) to the bearing housing circumference. Apply paste in a thin coherent layer by use of lint free cloth (**DO NOT rub in**). Use clean protective gloves. If applicable fit 'O' ring into the 'O' ring groove in the bearing housing circumference.

Bearing:

1. Apply half the specified bearing grease fill quantity (**see Table A-4**) to the upper face of the bearing (opposite side to the bearing designation markings).
2. Thumb the applied grease into the bearing, ensuring good penetration into the raceways / balls. Use clean protective gloves.

Assemble bearing into cartridge:

1. With greased face of the bearing facing the cartridge bore, assemble the bearing into the bearing housing. Ensure the bearing outer race contacts the location shoulder.
   Note: Only the outer race should be used to transmit load during assembly (NEVER use the inner race).
2. Apply half the specified bearing grease fill quantity (**see Table A-4**) to the free volume of the bearing.
3. Thumb the applied grease into the bearing, ensuring good penetration into the raceways / balls. Use clean protective gloves.

Assemble bearing onto shaft:

Bearing cartridge:

1. Heath the bearing / cartridge assembly to **90 – 100 ºC.**
2. Slide the bearing / cartridge assembly over the shaft, pushing it firmly against the bearing seating shoulder.
3. Rotate the assembly (including inner race) 45 ºC in either direction, to provide correct alignment. The bearing must be held firmly in place until it is cool enough to positively self locate. Ensure cartridge is at ambient temperature before assembling bracket.

Cap:

1. Apply the specified cap grease fill quantity to the inside face of the cap (**see Table A-4**).
2. Fill the grease escape slot, with grease.
3. Apply a small amount of grease to the grooved sealing surface in the cap.

Re-lubrication pipe:

1. Fill pipe and grease nipple.
2. Fit pipe work to machine.

Grease flinger:

1. Heat flinger to 180 ºC.
2. Slide flinger over the shaft and push it firmly against the bearing face. Hold in position until it is cool enough to positively self locate.
3. (If applicable) fit the wavy washer.
4. For bearing designation 6324 C3, a dummy cap must be fitted for assembly reasons. The correct cap is to be fitted after assembly of the NDE bracket onto the NDE cartridge.
5. Fit the cap over the grease flinger (**ensure flinger is at ambient temperature before assembling correct cap**) and into the cartridge.

Initial fill for P80 bearings – Kluber Asonic GHY72

Bearing Designation	Cage type	Grease Fill Quantity							
		Cartridge		Bearing		Cap		Total	
		cm^3	gram	cm^3	gram	cm^3	gram	cm^3	gram
6324 C3	Pressed Steel	170	151	340	302	170	151	680	604
6232 C3	Pressed Steel	136	121	272	242	136	121	544	484
6236 C3	Pressed Steel	195	173	391	348	195	391	781	694

Table A-4

Appendix 3

Tooling for spares:

Description	Tool No.
Rotor insertion tube	AF2049
Rotor insert tube support	AF2042
Dummy bearing cap	RT266
Dummy feet for NDE bracket removal	AF2081
Exciter pulling off equipment	AF2082
Packer for supporting rotor	AF2083
DE bearing / cartridge pull-off	AF1760
NDE bearing / cartridge pull-off	AF1761
Bearing / cartridge assembly tooling	AF2084

8. End of Life Disposal

Companies, specialising in reclaiming material from scrap products can reclaim most of the iron, steel and copper from the generator.

Recyclable material

Mechanically separate the base materials, iron, copper and steel, removing paint, polyester resin, and insulation tape and/or plastics residues from all components. Dispose of this 'waste material'

The iron, steel and copper can now be recycled.

Items requiring specialist treatment.

Remove electrical cable, electronic accessories and plastic materials from the generator. These components need special treatment to remove the waste from the reclaimable material.

Forward the reclaimed materials for recycling.

Waste material

Dispose of waste material from both of the above processes via a specialist disposal company.

AC GENERATOR WARRANTY

AC Generators

In respect of AC generators, the Warranty period is eighteen months from the date when the first goods have been notified as ready for despatch by the Company or twelve months from the date of first commissioning (whichever is the shorter period).

Defects after delivery
We will make good by repair or, at our option, by the supply of a replacement, any fault which under proper use appears in the goods within the period specified and is found on examination by us to be solely due to defective material and workmanship; provided that the defective part is promptly returned, carriage paid, with all identification numbers and marks intact, or our works or, if appropriate to the dealer who supplied the goods.

Any part repaired or replaced, under warranty, will be returned by the Company free of charge (via sea freight if outside the UK).

We shall not be liable for any expenses that may be incurred in removing or replacing any part sent to us for inspection or in fitting any replacement supplied by us. We shall be under no liability for defects in any goods which have not been properly installed in accordance with recommended installation practices as detailed in the publications Stamford Installation, Service and Maintenance manuals and Application Guidelines, or which have been improperly stored or which have been repaired, adjusted or altered by any person except ourselves or our authorised agents, or in any second-hand goods, proprietary articles or goods not of our own manufacture although supplied by us, such articles and goods being covered by the warranty (if any) given by the separate manufacturers.

Any claim under this clause must contain full particulars of the alleged defect, the description of the goods, the date of purchase, and the name and address of the vendor, the serial number (as shown on the manufacturer's identification plate) or for spares the order reference under which the goods were supplied.

Our judgement in all cases of claims shall be final and conclusive and the claimant shall accept our decision on all questions as to defects and the exchange of a part or parts.

Our liability shall be fully discharged by either repair or replacement as above, and in any event shall not exceed the current list price of the defective goods.

Our liability under this clause shall be in lieu of any warranty or condition implied by law as to the quality or fitness for any particular purpose of the goods, and save as expressly provided in this clause we shall not be under any liability, whether in contract, tort or otherwise, in respect of defects in goods delivered or for any injury, damages or loss resulting from such defects or from any work undone in connection therewith.

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Part Number: P80_MAN_EN_5